TWENTY-FOURTH ANNUAL REPORT 1950

CENTRAL STATES
FOREST EXPERIMENT STATION
Columbus 13, Ohio

Harold L. Mitchell, Director

CONTENTS

TWENTY-FOURTH ANNUAL REPORT

CENTRAL STATES FOREST EXPERIMENT STATION

1950

INTRODUCTION

One of the most important developments in the field of conservation during 1950 was appointment by the President of a Water Resources Policy Commission. This Commission was instructed to assemble and analyze all available information on the Nation's water resources and, on the basis of their findings, to develop a water resources policy for the country. As a result of this study, three reports were prepared and published. Not everyone will see eye to eye with the Commission on their recommendations. But all conservationists will agree that the Commission and cooperating federal, state, and private agencies have made a major contribution by bringing together a vast amount of valuable data never before assembled in one place. Moreover, the work of the Commission, especially the public hearings and published reports, brought forcefully to the attention of the general public the importance of the Nation's water resources and the need for a national policy to guide the conservation, development, and wise use of this indispensable resource.

Unlike so many studies dealing with water resources, the reports of the President's Commission did not neglect the role of forests in watershed protection and management. Early in the study the Forest Service was requested to prepare reports on forest conditions, forest-water relationships, and Forest Service programs in twelve of the Nation's major river basins. The Central States Station was assigned primary responsibility for the Ohio River. Because of the importance of this great river to much of the Central States territory, the highlights of the material assembled by the Station during this study are given a prominent place in our Annual Report for 1950.

Our Flood Control unit continued to cooperate with the Soil Conservation Service and other USDA agencies in conducting surveys to develop and appraise the effectiveness of land-use programs for reducing floods and sedimentation. In all, flood control field studies and report writing or revision were done in connection with eight watersheds in the Central States territory.

The fundamental studies in forest influences, soils, and silvics started at the Buckeye Branch in 1948 began to pay dividends. Some of the highlights of this research are presented for the first time in this report. Good progress was also made in the new range research program initiated two years ago at the Northern Ozark Branch.

Among the Station's major contributions during the year were publication of four reports dealing with various phases of the reclamation of lands stripped for coal. Research in the field of regeneration produced valuable data on direct seeding, ground preparation, methods of planting, and seed source.

Cutting of compartments in the comprehensive management study at the Kaskaskia Experimental Forest proceeded according to schedule. Farm forestry tracts in Iowa and Illinois were given their annual cut. New studies concerned with thinning and pruning of various forest types were started at all branch stations.

An important step was taken during the year with the initiation of a modest but much-needed fire research project in the Missouri Ozarks. This research is jointly sponsored by the Station, Region 9, and the Missouri Division of Forestry.

Our Forest Survey Division issued an analytical report on the forest resources and industries of Missouri. This report was well received and is now in its third printing. The first draft of the analytical report for Illinois was also completed during the year. Inventory field work in Indiana was completed in November 1950, and it is expected that the eight unsurveyed counties in southeastern Kentucky will be covered by June 1951. Forest-area and timber-volume statistics for Indiana and Kentucky will be compiled early in 1951. The drain data for these two states were assembled in 1950.

Cooperative marketing studies in Missouri and southern Illinois resulted in two publications of interest and value to the producers and users of forest products. The results of these studies are summarized in this report.

The annual logging and milling equipment demonstration sponsored by our Forest Utilization Service unit in cooperation with local organizations continued to attract the attention of operators and timberland owners. The 1950 show was held in southern Indiana and was attended by some 3,000 persons.

Many other activities and studies were carried on during the year. The results of these studies are given in some detail in the following pages. Also included is a section devoted to our plans for 1951.

In making our plans for next year we were mindful of the International situation and the impact of defense activities on our research program. During the latter part of 1950 the Station was called upon to do certain defense work and to help plan various other studies desired by the Army and other defense agencies. As defense activities are stepped up, the demand for special surveys, short-term studies, and similar defense work will undoubtedly increase. On the other hand, we can ill afford to lose sight of the importance of our forests to the Nation's economy or war potential. Long-term studies, basic to efficiency in the protection, management, and utilization of this important natural resource, must not be neglected. Keeping a reasonable balance between such research and the more immediate and pressing demands of the accelerated defense effort will present research administration with some problems--and a challenge.

PRESIDENT'S WATER RESOURCES POLICY COMMISSION

When the Ohio River flooded in 1937, more than 500,000 persons were driven from their homes and 65 were killed. The swirling waters caused damages estimated at 400 million dollars. Business and industry were paralyzed.

Far upstream raindrops hammered persistently first on snow-covered, then on barren hillsides. Rivulets became destructive torrents. Precious topsoil washed into the river by the ton, was carried downstream, and eventually settled to increase the already great silt deposits in the main channels and reservoirs.

The Ohio River Basin was suffering from too much water.

Yet at other times the rivers in this great basin are almost dry. Hardly enough water flows to wash away sewage and industrial wastes. Cities are finding it more and more difficult to maintain their water supplies. Farmers and rural communities have long noted a decline in the ground water level.

These problems and many others, multiplied by the thousands of rivers, cities, and rural communities throughout the country, led the President to appoint a Water Resources Policy Commission in January 1950.

The Commission's job was to assemble and analyze all available information on the Nation's water resources, and, on the basis of their findings, to develop a water resources policy for the country. Public hearings were held, and federal, state, and private agencies were called upon for data and suggestions. As a result of this study, three reports were prepared and published, A Water Policy for the American People, Ten Rivers in America's Future, and Water Resources Law.

At the request of the Commission, the Forest Service prepared reports on forest conditions, forest-water relationships, and Forest Service programs in twelve of the Nation's major river basins. The Central States Station was given primary responsibility for the report covering the Ohio River Basin excluding the Tennessee Valley. Some of the highlights of the material assembled for our report are given below:

THE OHIO RIVER BASIN

The Ohio River Basin extends from the Mississippi River to Western Pennsylvania and Maryland, from central Tennessee nearly to the Great Lakes. It includes more than 100 million acres of land, roughly 6 percent of the United States, and parts of 11 well-populated states.

The Ohio River flows through the center of the Basin in a generally southwesterly direction. Along it lies an almost continuous band of rough, unglaciated land that extends from the Ozark uplift of southern Illinois,

through the Knobs section of Indiana and Kentucky and the hill country of southeastern Ohio, into the mountainous headwater regions of western Pennsylvania, eastern Kentucky, and Virginia. North of this rough river-border country lie level or gently rolling glaciated lands that vary from poorly drained claypan soils to the rich, black soils of the fertile corn belt. To the south lie more level lands and swamp areas on the lower reaches of the Cumberland and Green Rivers, the famous bluegrass country of northcentral Kentucky, and farther east, the rugged, extensively forested basins of the Big Sandy, Kanawha, and Monongahela Rivers.

Forest cover.--Forests cover more than 34 million acres, about one third of the land in the Basin. In addition, there are an estimated 4 or 5 million acres of submarginal, worn-out agricultural lands and steep slopes that are best suited to growing timber and should be reforested.

The most extensive forests cover the mountains in the rugged headwater regions of eastern Kentucky, western Pennsylvania, and West Virginia where many counties are more than 80 percent forested. Even in the agricultural states of Illinois, Indiana, and Ohio, forests cover from 20 to 25 percent of the watershed.

Rainfall.--Rainfall in this watershed is generally ample for crop growth and is well distributed throughout the year, but occasionally the area suffers from droughts or flood-producing storms. Annual precipitation averages approximately 45 inches; about half falls during the growing season, April to September. Precipitation varies from less than 35 inches in the northwestern agricultural areas to well over 50 inches in the forested mountains in the southeast.

Watershed protection.--Because of their strategic location, the forests strongly influence stream flow and soil erosion. Although only one-third of the Basin is forested, the forests protect the most critical areas in the watershed. The Allegheny and Cumberland plateaus, for example, which receive the heaviest precipitation in the Basin, are well forested. The average annual water yield from these forested areas is two or three times that from the unforested agricultural areas in the northwest.

Forest ownership.--Public forest lands cover about 3 million acres, roughly 8 percent of all forest land in the Basin. Of this, about 2 million acres are in the national forests. State and county forests total less than one million acres.

More than 31 million acres, 92 percent of all forest land in the Basin, are privately owned. Many relatively large holdings of mine, lumber, and other industrial owners are scattered throughout the forest region, especially in the rugged eastern mountains. However, most of the private forest land is in small properties, much of it in farm woodlands. The future contributions of forest land to the economy of this area, therefore, depend largely upon the way these small forest holdings are treated.

WATER USE AND WATER PROBLEMS

Water requirements.--A dependable supply of usable water is essential to the health, welfare, and the very existence of the communities and industries throughout the Basin. More than 20 million people, roughly 15 percent of the Nation's population, live in this great basin. There are 150 cities of more than 10,000 population each. In these communities, the water required for home use alone is estimated to be 70 gallons per person per day.

A number of the Nation's largest industrial centers depend upon the water supplies in this basin. This area produces a large share of the Nation's steel, coal, and other minerals. Based on value of products, it produces one-third of the national output of iron and steel, and more than one-eighth of all goods manufactured in the Nation. In these industrial areas, the daily water requirement for both domestic and industrial uses is estimated at 150 gallons per person. The industrial demand for water is constantly increasing as new industrial processes are developed and industries expand.

Runoff and stream flow.--The primary problem in water management is regulating and controlling runoff and stream flow. The water supply in the Ohio Valley would be adequate if properly regulated. About the same amount of water is required throughout the year, but the supply varies from peaks which cause floods to extremely low flows which cause problems of pollution and supply. The maximum and minimum flows recorded at Metropolis, Illinois, for example, range from more than 700 percent to less than 10 percent of the average daily flow. The variation is even greater on many of the smaller tributaries. The flow of a tributary of the Monongahela at Elkins, West Virginia, has ranged from more than 2200 percent to less than 5 percent of the average daily flow.

Hydroelectric power.--At present, the use of water for generating electricity is relatively unimportant, because coal, oil, and gas are available for steam-powered turbines. Several hydroelectric plants are located on the major tributaries in the eastern mountains, and one is located on the main river at Louisville, Kentucky. The efficiency of these plants depends greatly upon the regularity of stream flow.

Supply and pollution.--The growing demand for water for industrial and domestic use, in the face of decreasing supplies and increasing pollution, is a major problem in such industrial centers as Pittsburgh, Charleston, Cincinnati, and Indianapolis. Air conditioning alone requires tremendous quantities of water, much of which is obtained from ground water wells. This additional drain on ground water is so heavy in many areas that the supply may become exhausted unless something is done to replenish it.

Population increases and new home uses for water, such as garbage disposal, are causing shortages in many cities. In some places lack of water suitable for manufacturing is limiting industrial growth. At the

same time the increased use of water for sanitation and stock watering has seriously depleted ground water supplies in a number of rural areas.

The threat of water pollution is always present. Bad enough during periods of normal stream flow, the harmful effects of pollution are intensified during droughts when there is not enough water to carry away the filth, much less dilute it.

Floods.--Floods not only cause great property damage, hardship, and misery, but at times take human life. Serious general floods have occurred on the Ohio an average of once every three years. According to records at Pittsburgh, flood stages have been reached or exceeded 115 times in 88 years (1855-1942), an average of once every nine months. Local floods on smaller tributaries do great damage even more often.

Navigation and sedimentation.--The Ohio River and its tributaries carry a greater tonnage per mile of length than any other river in the Nation. During 1947 more than 68 million tons of coal, coke, iron, steel, sand, and other products were carried on these rivers, chiefly on the Monongahela, Allegheny, and Ohio. The tonnage on these rivers makes up 28 percent of the total tonnage carried on the inland waterways of the United States. These important navigation channels are continually filling up with silt eroded from poorly managed lands. Dredging these channels to remove silt is the greatest single maintenance expense on the Ohio River waterways.

By reducing the amount of water a stream can carry, sedimentation also causes banks to overflow at lower water stages and cuts down the capacities of reservoirs in the watershed. These sedimentation problems are a result of soil erosion which in turn is largely a result of poor land management. Erosion is a major problem throughout the Basin; an estimated 25 percent of the watershed has been severely eroded--more than 75 percent of the topsoil lost. An additional 25 percent has been moderately eroded--25 to 75 percent of the topsoil lost.

FOREST USE AND FOREST PROBLEMS

Forests and the water problem.--Misuse and abuse of the land have greatly increased the water problem. This is probably more true of the agricultural lands than of the forest lands in the watershed. In the agricultural areas, the solution lies in good soil conservation practices and minor engineering structures in which forestry usually plays a minor part. This report is confined to the role of forest lands in the watershed.

Many of the water problems in the Basin are caused by the poor hydrologic condition of the forest land. Extensive overcutting, burning, grazing, and improper logging and utilization practices on vast areas of privately owned forest lands have reduced the protective forest cover. Soils once protected from the beating rain by a porous layer of leaf-litter and humus are now exposed to severe erosion.

Improper treatment of the forest land has so disrupted the normal cover-soil-water relations that the natural forces which usually regulate stream flow no longer function properly. As a result, much of the rain that would normally go into ground water storage now enters the streams immediately, often causing damaging floods. Surface runoff and erosion have increased so much that many streams in the forest region which once ran clear, now carry heavy sediment loads during and for many days following storms. If good forest cover were restored by using good forest management practices, soils would be stabilized and surface runoff retarded.

Because forest lands greatly influence water conditions throughout the Basin, watershed protection must be given high priority in managing these lands. However, since other uses of forest land also vitally affect the economy of the watershed, we must consider all of these forest land uses and their effect upon water conditions in the Ohio Valley.

Timber production.--The Ohio Valley produces much of the finest hardwood timber in the United States. Estimates based on the 1947 Census of Manufactures show that 20 to 25 percent of all hardwood timber produced in the Nation comes from this valley. Besides lumber, it produces large quantities of wood for valuable face veneers, cooperage stock, railroad cross ties, fence posts, fuel, paper, poles, piling, and many other products.

However, the Ohio Valley can no longer get all the timber it needs from forests within the watershed. The extensive timber stands which once covered almost the entire Basin have been completely removed from two-thirds of the watershed. Today the timber stand covers 34 million acres, about one-third of the Basin.

Lumber production has dropped from a peak of about 6 billion board feet per year at the turn of the century to less than 2 billion feet during 1947. The forests of the Basin now provide about half of the valley's lumber needs. Stands that once contained a large proportion of desirable softwood species have in many areas been taken over by inferior hardwoods which generally do not grow well on such sites. The proportion of softwood lumber in the total cut has dropped from 35 percent in 1900 to 10 percent at present. Almost 90 percent of all lumber imports are of softwoods, which are in great demand for construction purposes.

The present volume of growth is very low, primarily because of understocking. If rehabilitated, protected, and properly managed, these forest lands could produce more timber than the valley now needs, although some exchange of hardwoods for softwoods will probably always be necessary. They would provide additional employment, raise living standards, improve water conditions, and help to stabilize the economy of the entire forest region.

Grazing forest land.--Throughout the forest region, farmers supplement the income from their small marginal farms by running livestock in the forest. Even in the more prosperous agricultural areas,

woodland grazing is common. As practiced in the Ohio Valley, woodland grazing cuts both timber and watershed values of forest land. It usually destroys tree reproduction, reduces the quality and growth of the surviving trees, packs down the soil, destroys litter and humus, and decreases the infiltration capacity of the soil.

Forest land in the Ohio Valley is generally not suited to grazing. Studies conducted in several states within this basin have shown that forage gleaned from woodlands is much poorer than that from open pasture, both in quantity and in nutritional value. Livestock on woodland forage not only fail to gain, but often lose weight. The carrying capacity of improved open pasture may exceed that of woodland pasture by more than 20 to 1.

In this region more is usually lost in timber and watershed values than is gained from grazing forest land. If we are to have maximum timber production and watershed protection, forest land must be protected from livestock.

Recreation.--The states in the Ohio Valley have not taken full advantage of the recreational opportunities offered by the forest land. A number of other states, recognizing the value of forest land for recreation, have undertaken ambitious programs to develop areas for recreation. In many states recreation is now one of the leading industries.

Forest areas in the Basin that have been developed for recreation are overtaxed. The demand for outdoor recreation in this heavily populated watershed is great and is constantly growing. This demand could be met within the valley if camping and picnicking areas, summer home sites, and the game and fish resources were fully developed on the forest lands.

The value of water for swimming, boating, and especially fishing depends on the hydrologic condition of the watershed. Pollution, sedimentation, and irregular stream flow seriously reduce fishing opportunities.

Forest conditions also influence the number of deer, bear, ruffled grouse, wild turkey, and other forest animals. On good watersheds these animals get plenty of herbaceous food, water, and cover. As the forest cover is improved through better protection and management, recreational values will increase. Recreational facilities must be included in the forest land management program if we are to get the most from our forests.

ACTIVITIES ON NATIONAL FOREST LANDS

Federal forest lands in the national forests of the Ohio Valley total about 2 million acres. Most of these areas were badly depleted before they became part of the national forests. They are slowly being restored to full productivity under the multiple-use principle of management. Watershed, timber, forage, recreational, and wildlife values are

all considered in a program planned to correlate all uses and yield the greatest over-all benefits from the forest land. Although the national forests include only 6 percent of the forest land in the Basin, most of this land is located on the headwaters of the Ohio River. Watershed values are therefore given special consideration in managing national forest lands.

Recommended program.--The recommended program for national forest lands involves primarily an expansion and intensification of the present program. Although the minimum goals for fire control have been met, fire control is still considered inadequate, especially from the standpoint of watershed protection. If operating funds were increased, resource management activities could be intensified and the time needed to rebuild the forest to maximum productivity shortened. When fully restored, the national forest lands should produce a sustained annual yield of more than 300 million board feet of timber as compared to 33 million board feet at present.

The present program of land acquisition by purchase and exchange should be expanded to the extent necessary to consolidate federal ownership of nonagricultural lands within the boundaries of present national forests and purchase units. This is particularly important where privately owned tracts intermingled with federal lands are in need of rehabilitation to control erosion and regulate stream flow. Areas now outside the purchase units may ultimately be recommended for public ownership if this is the only way to protect the public interest in important watersheds.

SERVICES FOR NONFEDERAL FOREST LANDS

Probably the chief obstacles in rehabilitating the region's forest resource are the ownership pattern and the economic status of the owners. Most of these ownerships are small tracts. In the heavily forested hill lands bordering the lower Ohio and in the mountainous sections of eastern Kentucky, West Virginia, and western Pennsylvania, a majority of the small woodland owners have neither the money, the knowledge, nor the inclination to practice good forest management. Without public leadership and assistance, little will be done to restore watershed and timber values on these depleted lands. The public has a vital interest in the management of private forest lands since the condition of the forest cover on this large area seriously affects the economy of the entire watershed. Because of the great number of landowners involved, an adequate program will be both difficult and costly.

The present Forest Service program for nonfederal forest lands consists of cooperation with the states to help protect and manage the 32 million acres of these lands in the watershed. The program is inadequate, however, and should be expanded to restore these depleted forest lands as quickly as practicable. The cooperative activities include:

Protection.--With the exception of 6 to 7 million acres in Kentucky, all nonfederal forest land in need of organized protection

is now covered by state fire control organizations. The degree of protection varies by locality but generally fails to meet the goals set for minimum protection. More than 360,000 acres of nonfederal forest land were burned over during 1949.

Organized protection should be extended to include all lands in need of such protection, and should be intensified throughout the region, where needed, to meet at least the minimum goals for fire control.

Woodland management assistance.--Forest technicians give the woodland owners personal, on-the-ground help in managing and marketing timber. By increasing interest in good forest management practices, this help results in improved timber and watershed conditions and in greater profits to the woodland owners and operators. Although some 3,000 landowners are now contacted each year, the present staff of 30 forest technicians is unable to meet the demand for their services. Since more than a half million private woodland owners in the Ohio Valley would benefit by such services, this program should be expanded.

Reforestation.--Under this cooperative program, the states produce and distribute trees to private landowners for reforestation. This planting stock is usually sold at less than cost to encourage reforestation of idle and depleted lands. Present supplies fall far short of the demand for planting stock.

The 1949 output of all state nurseries in the Basin states totaled about 21 million trees, enough to plant approximately 21,000 acres. The area of potential forest land in need of planting is conservatively estimated at more than 5 million acres. At the present rate, more than 250 years will be required to rehabilitate the nonfederal lands in need of planting. Obviously, this program should be expanded.

BROAD MEASURES NEEDED TO SOLVE FOREST RESOURCE PROBLEMS

Watershed protection, timber production, recreation, and wildlife propagation are all closely allied. By correlating all such uses wherever possible, we will get greatest benefits from the forest land.

Rebuilding existing forest stands and reforesting bare lands best suited to forestry would do much to stabilize soils and retard damaging surface runoff. Rebuilding is much the same whether the objective is water conservation, recreation, or timber production. In managing rebuilt timber stands all of these objectives must be kept in mind.

In some areas a single use must be given priority. Rough areas covered with thin, erodible soils that produce only low-quality timber should be devoted primarily to watershed protection. Forest land adjoining lakes or streams, or located near cities, may be better for recreation than timber production. In most cases, however, forest land can be managed to conserve water and at the same time produce timber

and provide recreation. This has been demonstrated on the national forests, state forests, and some privately owned tracts in the Basin.

Fire control.--The first and probably most important measure needed to solve the forest resource problem is intensification of fire control. Without adequate fire control little can be done to restore and maintain the timber and watershed values of the forest land. Fire not only destroys tree reproduction and reduces the quality and growth of the surviving trees, but destroys recreational values, kills wildlife, and drives surviving game from the area. By destroying the ground litter and humus, it greatly impairs site productivity and watershed values. In most areas, present fire control activities fail to meet even the minimum requirements for forest land management. Intensified fire control is basic in the forest restoration program.

Forest management.--Better forest land management practices must be widely adopted to increase the number of thrifty, good-quality trees on these depleted forest lands. Logging practices must be improved so valuable timber can be removed with minimum damage to the watershed. Worn-out, submarginal agricultural areas and abandoned lands should be protected and made productive through reforestation. In most cases livestock must be kept out of the forest lands if maximum timber production and watershed protection are desired.

Research.--The Basin has many difficult forest problems; most of them have already been touched upon. Although research alone can solve none of the major problems, it can contribute to the solution of all technical forest and water problems. The federal government now spends about $303,000 per year for forest research in the Ohio Valley. State and private agencies in the Valley probably spend an equal amount for forest and related research. These programs, however, are inadequate and should be expanded.

Research must be continued and intensified to provide the information needed for a sound management program. We must find out more about the role of the forest land in the watershed, both from an economic and protection standpoint. Research is needed to determine the best land-use measures for correlating all forest land uses, and the best methods with which to reach the management goals. Money spent to develop efficient ways of rehabilitating and managing forest lands will be more than repaid by resulting savings in the field. Major research activities needed are described below:

1. Forest influence investigations.--Without adequate information regarding the influence of forest cover types and management practices on rebuilding exhausted soils, on soil stabilization, and on water conditions, no water conservation program can be effective. Yet very little is spent for research in this field. In contrast, millions of dollars are spent on remedial programs to control water, including structures and improvements. Research in forest influences will help safeguard this tremendous investment by pointing the way to the most beneficial land management practices for watershed protection.

2. Forest resource investigations.--Any sound watershed, industrial, or land-use plan requires information on the forest area and the present and potential forest resource. Effective marketing procedures, so necessary if the forests are to make maximum contributions to the local economy, depend on reliable forest resource information. Current forest resource investigations are providing this information and are helping to make current marketing methods more effective. These studies should be expanded to include new areas, and should be continued to keep such information up-to-date.

3. Forest products research.--All federal forest products research for the Ohio Valley is conducted by the Forest Products Laboratory at Madison, Wisconsin. Here investigations are conducted to solve the technical problems of the forest products industries and to increase the utility of wood by perfecting ways of processing wood and developing new wood uses. Continued research in this field may lead to new, profitable uses for low-quality timber which would make stand improvement cuttings economically possible, and would also save good-quality timber for better uses.

4. Forest management investigations.--Only a small start has been made on research to find out how to build up the forest cover, improve the quality and species composition of the stands, and increase their yield to the maximum in the shortest time at lowest cost. This is a major research problem because of the number of important forest and soil types in the watershed.

5. Additional research needs.--Fire control research is needed to develop more efficient methods and equipment for determining fire weather, and better methods of fire detection and control. Research is also needed to develop more efficient logging methods and equipment, with special emphasis on methods which cause the least possible disturbance and damage from the standpoint of soil erosion and water runoff. If light, mechanized logging equipment specially suited for use in farm woodlands were developed, farmers might be encouraged to manage their woodlands better.

SPECIAL PROBLEMS

The conflicting interests and conflicting policies involved in managing the Ohio Valley water resources are much the same as those in other river basins. Those of greatest significance in the Ohio Basin are:

Protection against sedimentation.--Stream structures and improvements are usually built without being adequately protected against sedimentation. For example, because of this neglect, sedimentation has reduced the capacity of the Columbus, Ohio, reservoir on the Scioto River almost 25 percent in the past 30 years. The city is now planning a new reservoir to increase the diminishing water supply. It is doubtful that adequate protective measures will be taken above the new dam.

Another case in point is the difficulty experienced in maintaining navigation channels on the Upper Ohio. Because of sedimentation, dredging is the greatest maintenance expense on these important waterways. Improved land management on both agricultural and forest lands could cut these expenses.

Private versus public interests.--This conflict involves the familiar problems of upstream versus downstream interests. Because of the forest land ownership pattern, this problem is acute in the Ohio Valley; 92 percent of the forest land is privately owned, most of it in small ownership tracts located upstream. Economic pressures force many of these small owners to follow poor forest management practices without regard to the effects downstream. Yet the heavily populated, highly industrialized downstream areas depend on the forested upstream areas for a large and continuous supply of water.

The public has a vital interest in the management of all forest lands. To protect this interest, every proper form of public assistance should be given private landowners. Many of these landowners probably could be reached by a more intensive program of education and technical assistance. Public regulation of cutting, if generally accepted and supported by industry and the public, would stop destructive practices on the larger private ownerships, but would be impractical to apply to the thousands of small, scattered woodlots which make up most of the forest area in the Ohio Valley. Public ownership is certainly needed in watershed problem areas and in localities where the forest resource is practically exhausted or where the land is too poor and unproductive to justify rehabilitation and management by private capital. More liberal credit on forest investments, and more favorable taxes on forest lands, would no doubt encourage private organizations and individuals to invest in and practice good forestry on large tracts of commercial forest land. Each of these measures could contribute to better forest land management. The answer to the forestry problems of the Ohio Valley probably lies in a combination of them.

Legislative needs.--Legislation may be needed to solve a number of water resource problems. In some cases, local or state governments may be able to handle the problems. In others, involving interstate interests, federal legislation may be required.

Stream pollution is one problem that may require such action. The Ohio River and its tributaries supply water for domestic and industrial use in many communities and industrial plants which line its banks. Unfortunately, the river is also the chief way of disposing of industrial and human wastes. Particularly during periods of low water flow, pollution is a menace to public health. Continuous re-use of the water as it moves down the stream increases the pollution problem. Strong action on the part of every river community will be required to solve this serious problem.

Zoning laws may be needed to prevent homes, industries, and even cities from being built on the river flood plains and to prevent uneconomic expenditures of federal funds to protect such properties.

Basin planning versus local planning.--The Ohio Watershed involves the interests of 11 states, innumerable county, township, and municipal authorities, as well as special groups such as the Ohio Valley Improvement Association, the Upper Monongahela Valley Association, the Little Kanawha Council, and the Muskingum Conservancy District. Many of these agencies are planning, carrying out, or supporting specific projects affecting the water resource. The projects usually favor the special interest of the organization without regard to the effect on the overall problems of the watershed. The different objectives of these various interests, without coordination and integration in the best interest of the Basin as a whole, lead inevitable to conflict.

Water and land uses.--As in other river basins, there are many conflicts between water and land uses. Storage reservoirs sometimes flood large areas of fertile bottomland or destroy areas of unusual recreational interest. For example, the proposed dam on the Green River in Kentucky may, if completed, flood lower levels of the famous Mammoth Cave.

Structures designed for flood control often obstruct navigation, hydroelectric development, and recreational use. An illustration of such a conflict is the proposed flood control reservoir on the Allegheny at Kinzua, Pennsylvania. If this high dam were built, the river could not be canalized to the Erie Canal, a project which would provide a water outlet for the steel, coal, and other heavy industries to New York and the Atlantic Seaboard.

CONCLUSION

By properly managing the farm and forest lands within the Ohio River Basin, most of the water problems of the region could be reduced or solved. This report emphasizes the role of forest lands. Properly managed forests not only portect the watershed, but produce more timber, provide food and cover for wildlife, and offer opportunities for recreation.

The problems involved in bringing about these conditions and improving the water resources throughout the Basin have been discussed in this report. Many of them could be solved by expanding and intensifying present programs. Others will require major policy decisions to resolve conflicts.

In any case, because forest lands greatly influence water conditions throughout the Basin, they must receive major consideration in developing a water policy for the Ohio River Basin.

PROGRESS AND ACCOMPLISHMENTS DURING 1950

FOREST INFLUENCES

Flood Control Surveys

The Flood Control Survey unit at this Station is engaged in the Nation-wide flood control surveys being conducted by the Department of Agriculture. The purpose of these investigations is to develop and appraise the effectiveness of land-use programs for reducing floods and sedimentation.

The Department of Agriculture's flood control activities are aimed at controlling water on the land, where it falls, while the Army program is directed at controlling water after it enters stream channels. Neither program can replace the other; both are needed; both should be closely integrated in any comprehensive flood control program.

The Department of Agriculture flood control surveys are conducted jointly by the Forest Service and the Soil Conservation Service. Other Departmental agencies cooperate in these surveys, acting chiefly as advisors in their fields of specialization, and have a voice in policy decisions. The Forest Service has primary responsibility for surveys on forested watersheds, while the Soil Conservation Service has the primary responsibility on watersheds where most of the land is used for agriculture. In either case, the Forest Service develops the remedial program for the forested parts of all watersheds and the Soil Conservation Service is responsible for program development on open land.

Flood control field surveys cover four related yet distinct phases: (1) preliminary examination, (2) survey work outline, (3) detailed survey and report, and (4) survey report review.

Preliminary examination.--When Congress has approved a flood control survey for a watershed, a preliminary examination is made to determine whether a program for flood control appears feasible enough to warrant a detailed survey. In the preliminary examination the data are obtained from a brief field examination of the watershed and from interviews with local people and state and federal land management agencies. The results are incorporated in the preliminary examination report. If this report indicates that a remedial program can alleviate the flood situation, a detailed flood control survey is authorized by the Secretary of Agriculture. If the preliminary report is unfavorable, further survey activity in the watershed must wait until Congress authorizes another examination.

Survey work outline.--After the preliminary examination, but before the detailed survey is started, a work outline must be prepared. This is a formal agreement or contract between the Soil Conservation Service and the Forest Service. It states the general procedures to be used in making the detailed survey, outlines and schedules the work to

be undertaken by each agency, sets up the organization of personnel by grades, and contains an estimate of the cost of the survey.

Detailed survey and report.--The detailed survey, which requires a considerable amount of field work and interviews with local people and state and federal officials, includes an analysis of the flood problem, the development of a remedial program, and a comparison of the benefits and costs of the program. The measures needed to ensure that the hydrologic condition of the woodland is brought up to a high standard and kept there usually include fire control, elimination of woodland grazing, forest planting, and technical assistance to woodland owners. To facilitate the program, public land acquisition is proposed where private owners cannot take part adequately in the proposed remedial program. The cost of the programs is distributed among the local people and the state and federal governments.

The program benefits the area by reducing flood-water peaks; reducing land damages from sedimentation; reducing the amount of sediment going into reservoirs, stream channels, and other works along streams, and enhancing property values. By increasing low-water flow it also increases power capacity, improves water quality, increases the quantity of water available for use, and improves the habitats of fish and other aquatic animals.

Non-flood-control benefits, sometimes referred to as "nonpublic," "conservation," "incidental," or "on-site" benefits, are those benefits that accrue to the land operator as a result of his taking part in the program. Such benefits include increased income from larger crop or timber yields. On-site benefits also include increased income from public lands and decreased costs of maintaining roads and highways.

Because the factors affecting runoff are interdependent, it is impossible to evaluate separately the effects of the individual remedial measures. However, flood control benefits can be evaluated separately from on-site benefits, and flood control costs can be separated from other costs. This permits us to develop flood control and over-all benefit-cost ratios, which form the basis for determining whether or not a remedial program is recommended for the watershed. To warrant a program, there is the legal requirement that all benefits must equal all costs; as a matter of Departmental policy, the flood control benefits must equal at least one-half the federal costs.

Survey report review.--The results of the investigations conducted during the detailed survey are incorporated in the flood control survey report. The report, prepared by the responsible agency with the collaboration of the other agency, is reviewed by the various field units within the agencies before it is submitted to Washington.

Status of surveys in Central States territory.--All the old survey reports were revised to conform with Departmental policies developed during the year. As in the past, the Soil Conservation Service was

responsible for most of the flood control surveys in our territory. The status of these surveys as of December 31 is given below:1/

Cuyahoga (Ohio).--The preliminary examination report and survey work outline were completed and field work was started.

East Fork of White-Patoka (Indiana).--The field revision of the report was completed. Region 9 agreed to the revised report which was submitted to the Forest Service Washington Office for review.

Galena (Illinois, Wisconsin).--The Galena River survey report will not be revised. This material was incorporated in the Upper Mississippi survey report.

Green (Kentucky).--The survey report was completed, agreed to by the cooperating agencies and the Washington Office, and submitted by Soil Conservation Service to the Secretary's Office.

Kentucky (Kentucky).--Field sampling was completed and program development started.

Red River of the North (Minnesota, North Dakota, South Dakota).--The preliminary examination report and watershed reconnaissance were completed and a survey work outline was started.

Root (Minnesota).--The Root River survey report was not revised. This watershed is included in the Upper Mississippi survey report.

Salt (Kentucky).--Responsibility for this survey was transferred to the Northeastern Station on July 1. At that time, the preliminary examination report (prepared by the Northeastern Station) and survey work outline were completed and damage investigations started.

Sangamon (Illinois).--No revision was made of the survey report. This watershed is included in the Upper Mississippi River survey report.

Scioto (Ohio).--The survey report revision was completed, agreed to by Region 9, and reviewed by the Forest Service Washington Office.

Snv (Illinois).--The revised survey report was completed, reviewed by the Forest Service and cooperating agencies, and is somewhere between the Secretary's Office and Congress.

Upper Mississippi (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Wisconsin, South Dakota).--The survey report was revised, accepted by Region 9, and submitted to the Forest Service Washington Office for review.

1/ All surveys except the Salt River survey are the responsibility of the Soil Conservation Service. The Salt River survey is under Forest Service leadership.

Whitewater (Minnesota).--As the Whitewater survey report is incorporated in the Upper Mississippi survey report, no revision will be made of this report.

Related activities.--Our Survey unit continued to cooperate with the Missouri Basin Inter-Agency Committee, and established liaison with the newly organized Arkansas-White-Red River Basin Inter-Agency Committee.

Forest Influences Research

The Station's modest program of forest influences research is carried on at the Buckeye Branch, Athens, Ohio, in cooperation with Ohio University.

Water movement and storage.--During the year we completed a preliminary study of the soil and stand characteristics which regulate the movement and storage of water in southeastern Ohio soils. The results of this study are being prepared for publication. Some of the more important findings are summarized below:

1. Infiltration rates generally are higher on forested land than on nonforested land having similar soils. On many old fields, especially where the soil is fine textured, infiltration rates are exceedingly low. The planting of native hardwoods is recommended for such sites. Tree roots near the surface decay and loosen the soil. This permits water to enter the soil more rapidly. The soil is further improved by the protective cover of hardwood litter and by the bonding of soil aggregates with organic matter. Except in very coarse soils, infiltration rates on compacted land are seldom satisfactory. Compaction prevents water from infiltrating pastured soils readily.

2. Percolation rates in nonforested soils probably depend upon the permeability of the least pervious soil horizon. In southeastern Ohio, subsoils generally are less pervious than surface horizons. Subsoils that contain more than 45 percent silt and clay are not readily permeable to water. Percolation rates in forested soils depend less upon the permeability of the individual soil horizons because in forest soils the profile is broken by tree taproots and their laterals. When these roots decay, the space they leave fills with very permeable materials. Thus percolation rates in forest soils depend in part upon the number, size, contents, and length of the roots or root cavities. The taproots of some hardwood species, such as white oak, the hickories, and black walnut, leave large spaces when their root systems decompose in place. The vertical penetration of their taproots, however, is slowed by rock fragments in the soil and is limited by horizontally bedded clays and shales.

3. The total amount of water withheld from downward movement is somewhat greater on forested than on nonforested land. Water absorbed by the litter horizon and organic matter in the surface soil on forested land accounts for this difference. However, these factors do not influence water storage nearly as much as does the texture of the soil.

Root concentration.--Our studies on the concentration of roots under stands of white oak show that the number of small roots decreases rapidly with soil depth. The concentration in A_1 horizons exceeds that in the A_2 horizons by $2\frac{1}{2}$ times, while the concentration in the uppermost subsoil horizon is about one-half that of the A_2. The total number of small roots in the A_1 and A_2 horizons equals the number found in deeper horizons despite the fact the soil volume in A horizons is small compared with the subsoil volume containing roots. On the average, the weight in tons per acre-foot of roots one-fourth inch and less in diameter is 7.8, 3.2, 1.8, and 1.4 for the A_1, A_2, first, and second subsoil horizons, respectively. The first three feet of the average profile for even-aged white oak stands in southeastern Ohio contains about 7.4 tons per acre of these smaller roots. The concentration of the small roots of white oak is greatest near the tree's trunk and decreases to a minimum near the edge of the canopy. This is true in all soil horizons. A manuscript summarizing these results was prepared for publication as a Station Technical Paper.

During the year we also started an investigation of the relation of root concentration to other stand, soil profile, and topographic characteristics. There is a great need for quicker, cheaper methods of investigating tree root systems.

Silviculture

Walnut pruning.--A comprehensive study concerned with improving black walnut stands on strip-mined lands in Kansas was started in the spring of 1950. In making this study, we pruned trees of various sizes to a wide range of clear lengths and removed different amounts of living crowns. We hope also to get data on the effects of pruning on branching and decay. This study is being carried on in cooperation with the American Walnut Manufacturers Association.

The two plots in this study were established on mine banks in Crawford County, Kansas. The 720 individually selected trees are in pure stands of black walnut planted about 16 years ago by the Civilian Conservation Corps. The study trees were pruned in January and February. Four intensities of pruning--0, 25, 50, and 75 percent of the live crown removed--were applied to three sizes of trees--3-, 4-, and 5-inch d.b.h. classes. Each pruning intensity was applied to two groups of 30 trees in each d.b.h. class. Five trees in each group of 30 will be dissected at intervals to determine the origin of sprouts, the time required for clear wood to form over the pruning wounds, the decay hazard, and the quality of wood.

The data taken on the study trees before and after pruning are summarized in tables 1 and 2. In some respects the 4-inch trees are more nearly like the 5-inch trees than they are like the 3-inch trees. For example, 89 percent and 100 percent of the 4-inch and 5-inch trees, respectively, are in the dominant and codominant crown classes, while only 60 percent of the 3-inch trees are in these classes. Also, the 4-inch trees are 1.9 feet shorter than the 5-inch trees but 3.6 feet taller than the 3-inch trees.

The height to the first branch (clear length) before pruning averaged only 2.0 feet for trees in all d.b.h. classes. The height to the lowest live branch averaged 5.5 feet. This means that the quality of the wood on a 3.5 foot section of the bole was being lowered by persisting dead branches.

Removing 25 percent of the crown cleared the main stems to about 38 percent of the total tree height. Removing 50 and 75 percent of the crown increased the clear portion of the stem to 46 and 60 percent of the total tree height. Increasing the amount of crown removed from 25 percent to 75 percent cleared only an additional 22 percent of the main stem.

Pruning decreased the width of crowns and resulted in a more open canopy. Study trees had an average of 1.7 sides open (one side equals a 90-degree arc on the perimeter of the crown) before pruning and 2.4 sides open after pruning. This represents a 40 percent increase in lateral growing space for the crowns of the study trees.

Table 1.--Description of trees used in the walnut pruning study

D.b.h. classes	D.b.h.	D.o.b. at 9 feet	Total height	Dominant and codominant trees	Intermediate trees	Average number of sides open: Before pruning	Average number of sides open: After pruning
	Inches	Inches	Feet	Percent	Percent	Number	Number
3-inch	3.02	2.24	20.7	60	40	1.8	2.3
4-inch	4.00	3.12	24.3	89	11	1.5	2.4
5-inch	4.97	3.88	26.2	100	0	1.8	2.5

Table 2.--Treatment of trees used in the walnut pruning study

D.b.h. classes and treatment	Height to first branch	Height to first live branch	Width of live crown
	Feet	Feet	Feet
3-inch			
Before pruning	2.2	5.2	6.4
After pruning 25 percent	--	8.5	5.2
After pruning 50 percent	--	9.5	4.8
After pruning 75 percent	--	12.7	3.8
4-inch			
Before pruning	1.9	5.7	7.7
After pruning 25 percent	--	9.4	6.2
After pruning 50 percent	--	11.6	5.4
After pruning 75 percent	--	14.6	4.6
5-inch			
Before pruning	2.0	5.6	9.6
After pruning 25 percent	--	9.2	7.6
After pruning 50 percent	--	11.8	6.7
After pruning 75 percent	--	15.2	5.2

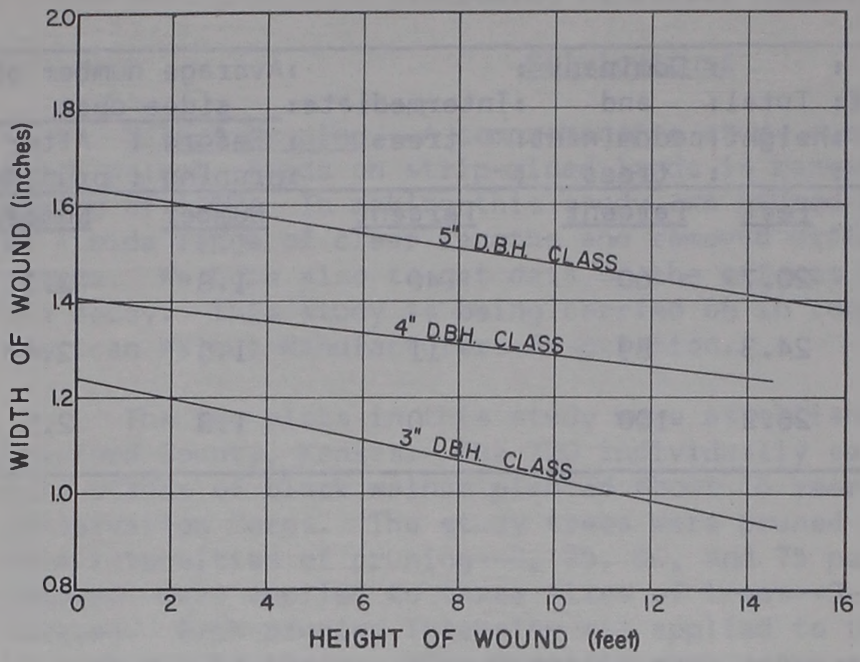

Figure 1.--Width of wound by height of wound for the 3, 4, and 5 inch d.b.h. classes.

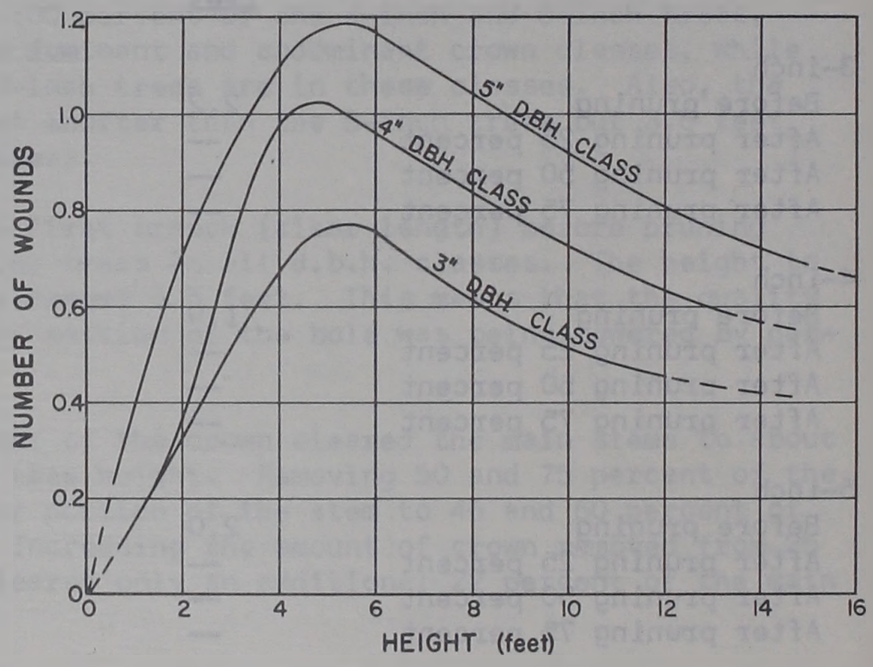

Figure 2--Number of pruning wounds per lineal foot on bole for 3, 4, and 5 inch d.b.h. classes.

The average width of pruning wounds at all heights on the bole increased with an increase in the diameter of the tree (fig. 1). The width of the wounds decreased with an increase in their heights on the tree. The average number of pruning wounds per lineal foot of tree stem increased with tree diameter (fig. 2). The frequency of wounds on all sized trees increased sharply with an increase in height on the stem to a height of about 5 or 6 feet and then decreased gradually to a height of about 14 feet. Natural shedding of the lower branches is responsible for the lower number of wounds on the lower trunk. Longer internodes above a height of 6 or 7 feet, because of a higher growth rate, account for the lower frequency of wounds on that part of the boles.

Jack pine pruning.--Jack pine in the pruning study plots established two years ago in a plantation on the Shimek State Forest in southeastern Iowa were remeasured during the year. The trees were also repruned to maintain the desired live crown length.

We found that during the two years following treatment the trees grew less in both height and diameter with increasing severity of the pruning. As shown below, reducing the length of live crown by 25 or 50 percent produced only slightly less height growth, but the reduction in diameter growth for the 50-percent-pruned trees is significant.

Approximate reduction in live crown (Percent)	Height growth (Feet)	Diameter growth (Inches)
0	4.20	0.62
25	4.17	0.58
50	4.05	0.50
75	3.39	0.24

Optimum stocking for oak-hickory.--During the year we completed installation of a study set up to provide information on the stocking required for maximum growth of the even-aged oak-hickory stands typical of southeastern Iowa and northeastern Missouri. One-fifth-acre plots were established in 25- and 50-year-old stands on the Shimek State Forest in Lee County, Iowa.

Four plots for each of four treatments and a check were set up in the 25-year-old stands. The planned treatments provided for leaving basal areas of 60, 50, 40, and 30 square feet per acre in this age class. In the 50-year-old stand, three replications were provided for each of four treatments to leave 80, 65, 50, and 35 square feet of basal area per acre. The basal areas remaining after cutting corresponded quite closely with those planned.

Twenty crop trees were selected on each of the 35 one-fifth-acre plots, a total of 700 trees in all. Data were collected on diameter, usable height, form class, or form point on pole-size trees, and crown class. "Before and after" photographs were taken from permanent points.

We plan to remeasure these trees periodically to find out the influence of treatment on growth rate, quality, and other stand characteristics.

Data on the basal area, volume, and number of stems on the plots, before and after treatment, are shown in table 3. With basal area as the control, considerable variation resulted in the remaining volume in cubic feet.

White oak is the most common species in the remaining stand, comprising two-thirds to three-fourths of the basal area and volume. The rest of the stand is composed largely of the other oaks, with some hickory, elm, and other minor species.

Optimum stocking for shortleaf pine.--A comprehensive stocking-thinning study was started during the year in second-growth shortleaf pine stands on the Sinkin Experimental Forest in Missouri. This study will be carried out on one-fifth-acre plots. The treatments include five degrees of stocking--50, 70, 90, 110, and 130 square feet of basal area per acre--and three methods of thinning--from above, from below, and by individual tree selection. The effects of the treatments will be measured in terms of quantity and quality of wood produced.

In addition to the study described above, seven sets of thinning plots were established on timber-sale areas of the Clark and Mark Twain National Forests under different site and stand conditions. As opportunities arise, additional plots will be set up on other timber-sale areas.

In connection with the establishment of these plots, enough data were collected to adjust and extend existing volume tables for use on the small, second-growth pine trees involved in these experiments.

Thinning shortleaf pine.--A cooperative study on thinning shortleaf pine plantations was established on the Hoosier National Forest in Indiana. Light, medium, and heavy thinnings from above and below were used in a 14-year-old plantation. Basal area before cutting varied between 113 and 144 square feet per acre. Treatments gave remaining basal areas of 80, 100, 120, and control. Posts, 8 feet long to a minimum top diameter inside bark of $2\frac{1}{2}$ inches, were cut from the trees removed in the thinnings. Number of posts removed per acre were as follows:

Remaining basal area (Sq. ft.)	Thinning from above (Number of posts per acre)	Thinning from below (Number of posts per acre)
80	440	560
100	350	50
120	90	0

Table 3.--Summary of stocking per acre by treatments before and after cutting of two age classes

Item	25-year-old stand						50-year-old stand					
	Treatment					Aver-	Treatment					Aver-
	A	B	C	D	Check	age	J	F	G	H	Check	age
Basal area[1]												
Original	81	72	84	79	74	78	102	92	88	89	86	91
Cut	21	22	44	49			23	28	37	54		
Remaining	60	50	40	30	74		79	64	51	35	86	
Volume in cubic feet[2]												
Original	410	318	454	398	328	383	1072	866	885	950	897	934
Cut	40	41	155	193			184	177	309	530		
Remaining	370	277	299	205	328		888	689	576	420	897	
Number of stems[1]												
Original	775	735	740	770	815	768	340	335	290	320	300	318
Cut	310	335	470	535			130	145	160	215		
Remaining	460	400	270	235	815		210	190	130	105	300	

1/ Basal area and number of stems include only stems 2.6 inches d.b.h. or larger.

2/ Volume in cubic feet to usable top of not less than 3 inches for poles, and 8 inches for sawlog-size trees.

The appearance of the plots just after cutting indicated that thinning from above might be just as desirable as from below. However, future growth, development, spacing, and condition of the stand may change this preliminary indication.

Growth of older plantations on spoil banks.--In Indiana we studied 26 successful coal company plantings which ranged from 15 to 24 years of age. The study was made to find out how the growth and volume of trees in older plantations are affected by species composition and major spoils characteristics. The following observations are based upon preliminary analyses of these data:

1. On moderately acid spoils, the growth of hardwood species planted in mixtures which included black locust has been good. These hardwoods have grown an average of 1.5 feet in height per year. The average merchantable volume of all sampled plantations 20 years old or older was slightly over 800 cubic feet per acre. All stems having a minimum length of 8 feet to a 3-inch inside-bark top diameter were considered merchantable. With this diameter limit, and a minimum length of 7.5 feet, these stands contained nearly 900 posts per acre.

2. The average volume at 20 to 22 years of age for all coniferous plantations measured in this survey was 850 cubic feet, 10.7 cords, or 995 posts. One 22-year-old mixed planting of red and jack pines contained 1,116 cubic feet, 14 cords, or 1,533 posts.

3. In pine plantations having row-by-row mixtures of species with different growth rates, such as jack pine and red pine, many of the slower-growing species have been suppressed and now contribute little to stand productivity. Mixtures by blocks or multiple rows probably would have produced better form and more uniform growth of all species.

4. The height and diameter growth of black walnut planted in mixture with black locust has been nearly twice that of pure walnut plantations of similar ages.

5. In the well-stocked pine stands, diameter growth started falling off when the trees were from 8 to 10 years old.

6. The position of planted trees on the spoil banks affected their rate of growth. In the plantations examined, trees on the lower portions of banks averaged 4 feet taller than those on the upper portions. The influence of bank height on tree growth appears to be greater on spoils of light texture.

Growth of white pine.--Station Note No. 61, Growth of a White Pine Plantation in Iowa, was published during the year. This report deals with growth and other characteristics of a 53-year-old white pine plantation in central Iowa.

Silvics

Leaf samples collected by a standardized method from various tree species growing on a wide variety of sites were analyzed for nitrogen and other nutrient elements. The purpose of these studies is: (1) to obtain additional information on the nutrient requirements of the trees, and (2) to measure, in terms of availability to tree species, the chemical fertility of the various sites.

In one study leaf samples were taken from trees on plots established in even-aged white oak stands on 33 different sites in southeastern Ohio. The stands ranged in age from 30 to 114 years. Site index varied from 47 to 77, and the nitrogen content of the leaves from 1.62 percent to 2.57 percent.

A highly significant correlation was found between the nitrogen content of the leaves and site index. On the poorest sites the nitrogen content of the leaves, probably the best measure of nitrogen availability, averaged less than 1.8 percent. On the better sites, as determined by site index, the nitrogen content of the leaves averaged considerably above 2.0 percent, and ranged up to 2.57 percent. These data are in line with the results of previous studies which indicated that, other factors being equal, internal (leaf) nitrogen concentrations of 2.7 and above are necessary for maximum growth of white oak. They also show that many of the forest sites in southeastern Ohio are deficient in nitrogen, so far as growth of white oak is concerned. For trees with higher nitrogen requirements, such as yellow poplar and ash, these sites are seriously deficient in this essential element.

The nitrogen content of the leaves of white oaks showed a significant correlation with the depth of the A_1 soil horizon, but was not significantly related to the age of the trees. There was no relationship between the phosphorus content of the leaves of white oak and the growth of this species. Apparently the sites studied are not deficient in phosphorus.

In all studies in which hardwood seedlings were planted in mixture with black locust the growth and the nitrogen content of the leaves of the other species were significantly greater than when planted without the locust. These results have been observed in plantings on old fields, spoil banks, and other sites known to be or suspected of being deficient in nitrogen. Data from one such experiment, conducted on stripped lands in southeastern Ohio, are as follows:

Species	Nitrogen content of leaves (Percent)	Total height (Inches)
Yellow poplar		
Mixed with black locust	2.34	132
Pure stands	1.41	58
Green ash		
Mixed with black locust	2.47	110
Pure stands	1.47	41

Management of Upland Hardwoods in Southern Illinois

The cutting and harvesting phases of the comprehensive upland hardwood management study at the Kaskaskia Experimental Forest were continued during the year. A series of 36 compartments, averaging about 20 acres each, were established in 1948. They are equally divided between the oak-hickory and the mixed hardwood forest types. The costs and returns from several systems of forest management are being tested on these areas. Some of the comparisons we will make are:

a. Even-aged and uneven-aged management.
b. Long and short rotations.
c. Long and short cutting cycles.
d. Intensive and extensive management.
e. Several combinations of these variables.

To date all cutting and improvement treatments have been completed on 12 compartments, covering 206 acres. We have also started work on eight additional compartments, covering 172 acres. Felling and bucking have been done with the conventional two-man crosscut saw. A track-laying tractor with single-drum winch, and a small rubber-tired sulky have been used for skidding and yarding the logs. The average harvesting costs for three intensities of cutting are shown in table 4.

Table 4.--Average harvesting costs in man-hours and equipment-hours for three intensities of cutting

Intensity of cut	Net volume removed	Man-hours felling and bucking	Skidding and yarding	
			Man-hours	Equipment-hours
	M bd. ft.	Per M bd. ft.		
1,200 bd. ft./acre	79,775	12.0	3.5	0.8
Clear cut to 10.5 inches d.b.h.	60,515	15.9	4.0	1.0
600 bd. ft./acre	59,500	12.2	3.7	0.9

As may be seen from this summary, clear-cutting to 10.5 inches d.b.h. has been the most costly of the three cutting intensities. There was very little difference between the costs for cutting 1,200 and 600 board feet per acre.

Culls and other undesirable trees were eliminated as a part of the stand improvement treatments on compartments receiving intensive management. The smaller trees and others which could be girdled effectively with an axe were killed without poisoning. Trees having deep fire scars with ingrown bark and others that were difficult to girdle with an axe were killed with ammate. We have completed these stand improvement treatments on 8 compartments, comprising 117 acres. An average of 31 trees per acre, having an average d.b.h. of 7.8 inches, have been treated. These treatments cost an average of 1.7 man-hours of labor and 0.75 pounds of ammate crystals per acre.

Farm Forestry

Kaskaskia.--The second annual cut was made on the 24-acre "good" farm woodland at the Kaskaskia Experimental Forest in southern Illinois. The tract is divided into three equal blocks. Slightly less than the total annual growth of the entire woodland is harvested from one of the blocks each year. The timber stand will be improved gradually through intensive improvement treatments. Although the first few cuts will be made primarily for stand improvement, some products will be obtained. We will maintain records for the products removed, costs of improvement treatments, and returns from products sold. So far we have harvested these products from the first two 8-acre blocks:

Cabinet veneer logs	570 bd. ft. (International 1/4-inch scale)
Sawlogs	8,325 bd. ft. (International 1/4-inch scale)
Bourbon stave bolts	26.5 chord feet
Mine props	720 linear feet

Based upon current local prices, these products, laid down at roadside had a gross sales value of $220.47.

Paint Creek.--The first harvest cutting on the farm forestry tract at the Paint Creek Experimental Forest in northeastern Iowa was started in late December 1949 and completed in February 1950. The operation produced 28,495 board feet of logs. Average cost of production was $28.23 per thousand board feet (table 5). Of this amount, about 18 percent, or $5.06 per thousand, was chargeable to transportation and travel time for the logging crew.

With rough, mill-run lumber retailing for about $70 per thousand board feet, and milling and selling costs of about $30, a small margin--$11.73 per thousand--is left for stumpage and profit with these logging costs. We believe the costs can be substantially reduced in future operations.

Table 5.--Costs of sawlog production on a farm forestry tract, 1949-1950

Item	Compartments			
	I	III	IV	Average
	-Board-foot volume-			
Sawlog production	11,770	10,050	6,675	28,495
	-Cost per M board feet-			
Felling and bucking	$10.67	$11.42	$ 9.75	$10.72
Skidding	7.24	5.70	7.06	6.66
Loading	2.82	3.27	4.17	3.29
Hauling and unloading	2.05	1.74	2.26	1.99
Road construction	--	1.43	--	0.51
Total, excluding travel	$22.78	$23.56	$23.24	$23.17
Travel costs[1/]	5.60	5.26	3.86	5.06
Total, including travel	$28.38	$28.82	$27.10	$28.23

1/ Includes time allowed laborers while enroute to work area and costs of transporting them in a truck.

Mensuration

Tree volumes.--Aids for Computing Tree Volumes in Illinois was published in August 1950 as Technical Paper No. 115. This paper gives species correction factors, average form classes, bark ratios for converting the volume of rough wood to a peeled-wood basis, bark thicknesses for ease in determining form classes of standing trees, and cubic volumes for pole-size trees. We included a handy pocket-size copy of the correction factors and average form classes for use in a field notebook.

In addition, the Station assisted the Shawnee National Forest in completing analysis of volume and growth data obtained during the recent timber survey of the Forest. The results of this survey will be used in revising the Forest's management plan.

Our staff specialists assisted the research centers in planning management studies, constructing local volume tables, and reviewing work plans and reports. Average form class comparisons between states were made as new data became available. Volumes and merchantable heights of pole-size trees and volume growth rates were also compared between states.

White oak site index.--In 1950 a manuscript was completed that presented the results of a study made to find the effect of stand density on the estimation of white oak site index. This paper has been accepted for publication in the Journal of Forestry.

We found that the height growth of white oak growing in southeastern Ohio is modified by the density of the stand; if precise site-index determinations are to be made, this factor should be considered. The influence of density was investigated by collecting data from 51 two-tenth-acre plots in southeastern Ohio. The mean age of the stands varied from 30 to 114 years. All trees breast height or taller were measured by one-inch diameter classes and total height of the dominant white oak trees was obtained with the Abney level and surveyor's chain. Conventional site index was determined for each plot by the height-growth pattern observed. Stand density of each plot was computed using Chisman and Schumacher's tree-area ratio.2/

The influence of stand density on site index became evident when the estimates of site index from a logarithmic equation were plotted over the plot densities. The trend was linear and the addition of density as a variable made a significant difference in the site-index estimates. For example, we found that the estimates of site index might vary by a full site-index class when extremes in density are considered. Such variations could make a difference of 10 to 20 percent in estimating total cubic-volume yield.

The site-index equation for white oak in southeastern Ohio considering density was found to be:

$$\text{Log site index} = \text{height} + \frac{11.638}{\text{age}} - 0.129 \text{ stocking norm} - 0.103$$

Fire

Late in 1950 action was taken to start a modest fire research project in Missouri, where the fire problem is more acute than elsewhere in the Station territory. This project will be sponsored jointly by Region 9, the Station, and the Missouri Division of Forestry.

The importance of fire control in Missouri forests and the need for fire research to help develop better fire prevention and control programs have been recognized for many years. Nearly half of the forest fires occurring each year on national forests in Region 9 burn on the Clark and Mark Twain National Forests of Missouri. The Clark National Forest alone has as many fires as the eight northern forests combined. Even so, the number of fires that burn on the national and state forest

---

2/ H. H. Chisman, and F. X. Schumacher. On the tree-area ratio and certain of its applications. Jour. Forestry 38:311-317. 1940.

protection areas is a relatively small part of the total number of fires that occur in Missouri. It is estimated that there are over 6,000 woods fires in Missouri each year.

A negligible number of these fires result from natural causes; the rest are caused by man. Most of the fires are set intentionally. These incendiary fires point up a conflict in land use that is deep-seated in the social and economic background of the people. Woods burning has been practiced since the first settlers came to Missouri. The most commonly stated reasons for burning are: to improve grazing; to get rid of ticks, snakes, and predators, and to keep down the brush.

Unrestricted burning of the woods, however, is not compatible with good forest and water conservation practices. On lands devoted to timber production and watershed protection, fires must be prevented or quickly controlled. A great deal of progress has been made in fire prevention during the 16 years since organized protection has been in force, but there is still much to be done.

Fire prevention and control require large sums of public and private funds each year. If these funds could be used more efficiently, we would have better protection and could release manpower for more productive activities. Although fire prevention and control are costly, uncontrolled burning must be curtailed if the forests and forest industries are to contribute their fair share to the economy of the area.

Research, by helping to define and measure the factors of fire danger and fire effects and by helping to evaluate methods and performances, can contribute toward more effective fire prevention and control.

Regeneration

Forestation of lands stripped for coal.--During the year most of the experimental plantings established on spoil banks since 1946 were re-examined, and a number of new studies were started. We also made some progress in publishing material obtained in earlier investigations.

Remeasurements of trees planted in Ohio, Illinois, and Kansas to test the effects of grading strip-mined lands continue to show the harmful effects of grading on survival and growth. For most species and sites the early development of planted trees has been distinctly better on undisturbed strip-mined lands than on those altered by grading (table 6). The detailed results of these studies for the experiment in Illinois were published in 1950 as Station Note No. 62.

The large-scale experiments set up in Ohio in 1946 to test the suitability of tree species to various spoil types were remeasured in 1950. Our preliminary analysis of this information shows that for all species planted except black locust, growth has been almost twice as great on the moderately acid shaly spoils as on the calcareous clays.

Table 6.--Comparative survival and height of planted trees on graded and ungraded strip-mined lands

Location of tests	Species	Age of planting	Survival: On graded spoils	Survival: On spoils not graded	Total height: On graded spoils	Total height: On spoils not graded
		Years	Percent	Percent	Feet	Feet
OHIO						
Harrison County	Yellow poplar	5	14	47 1/	0.6	1.6
	White ash	5	94	91	2.5	4.3
	White pine	5	70	77	1.1	1.4
	Black locust	5	96	99	17.3	19.5
Columbiana County	Yellow poplar	5	75	70	2.0	2.5
	White ash	5	95	93	3.0	3.7
	White pine	5	92	91	2.1	2.4
	Black locust	5	97	100	16.8	16.9
ILLINOIS						
Saline County	Green ash	3	87	86	1.3	1.7
	Black locust	3	97	92	8.5	8.5
	Sweet gum	3	52	74	0.8	2.2
	Loblolly pine	3	18	73	1.0	2.9
	E. redcedar	3	77	79	1.0	1.2
	Shortleaf pine	3	21	52	0.6	1.7
KANSAS						
Crawford County	Jack pine	4	8	25	2.6	2.6
	E. redcedar	4	51	53	2.2	2.7
	Black locust	4	72	93	10.7	13.9
	Green ash	4	45	59	2.2	2.8
	Black cherry	4	20	64	1.7	2.1
	Virginia pine	4	20	51	2.2	3.4
	Pitch pine	4	18	43	1.6	1.8
	Bur oak seed	4	25	30	0.4	1.5
	Sycamore	3	16	54	1.6	2.7
	Shortleaf pine	3	34	48	0.9	1.6
Number of cases significantly superior			0	13	0	16
Number of cases not significant			11		8	

1/ Underscored figures show marked superiority over their counterparts on the other type of spoil.

However, survival has been better on the latter sites. These data, together with results from measurements on additional experimental areas in 1951, will be the basis of a progress report to be prepared in 1952.

Experimental plantings set up during the past four years to study the effects of mixing black locust with other hardwoods are still too young to yield significant results. Older plantings, however, indicate that hardwoods grow much better when mixed with locust than when planted without this species. Foliar analyses, moreover, have shown that the nitrogen content of leaves--a measure of nitrogen availability--of yellow poplar, white ash, and Eastern redcedar was significantly higher when grown in mixtures with black locust than when each was grown in pure stands.

Underplanting in black locust stands is also proving successful, particularly where ground cover is not too dense to prevent good initial survival. In tests on strip-mined lands in Illinois, the height of black walnut, silver maple, and yellow poplar at the end of the third growing season was 2 to 4 times greater under a black locust overstory than in open, more exposed sites. Detailed results of these tests were reported in Station Note No. 63.

We started several additional spoil-bank planting experiments during the year. Cuttings of cottonwood and nine hybrid poplars were planted on graded and ungraded spoils in Ohio; growth of some of these clones during the first growing season was surprisingly good. Kentucky coffeetree, European larch, and chestnut oak were planted on adjacent sites. Some direct seeding of shortleaf pine and white oak was made on partially graded spoils in Ohio.

We also planted European larch on several strip-mined areas in southern Illinois; at the end of the first growing season, however, nearly all seedlings died. Although this species has been established successfully on spoil banks elsewhere, particularly in Pennsylvania, it does not appear promising here.

Large-scale planting experiments to test the value of mixing black locust with other hardwoods were set up on spoil banks in Illinois and Kansas in the spring of 1950. The plantings in Illinois were established through the cooperation of the Illinois Coal Strippers Association and the United Electric Company; those in Kansas were made possible through the cooperation of the Pittsburg and Midway Coal Company.

We continued to study the possibilities of producing Christmas trees on strip-mined lands in southern Illinois. Five additional acres were planted to red pine, Scotch pine, and jack pine. This study was begun in 1948 with the cooperation of the Illinois Coal Strippers Association, the United Electric Coal Company, and the Illinois Central Railroad.

In addition to the Station notes already mentioned, two technical papers were published during the year: Overburden Analyses and Strip-Mine Conditions in Mideastern Ohio, and Overburden Analyses and Strip-Mine Conditions in Northeastern Ohio.

Formal cooperative agreements authorizing forest planting research on stripped lands in Illinois and Indiana were entered into with the Illinois Coal Strippers Association and the Indiana Coal Producers Association. These agreements provide for joint financing of research projects of mutual interest.

Fall planting of old fields.--During the year we compiled and analyzed the results of a series of fall-planting experiments conducted in southern Illinois. In these studies, hand and machine planting methods were tested on a variety of vegetational cover-types. The results strongly indicate that fall planting can be done successfully if no scalp is removed and if the cover consists of heavy broomsedge or broomsedge mixed with briars and brush. Frost heaving was slight in areas planted under these conditions. The data have been summarized and a technical paper is being prepared. Using the results of these studies as a guide, the Shawnee National Forest is testing fall planting of shortleaf pine on a relatively large scale.

Direct seeding.--We continued to test machine seeding of shortleaf and loblolly pine in southern Illinois. A pilot-plant study of machine seeding of these two species was started in March 1950. In October a 10-acre field was furrowed to prepare the site for additional seeding studies scheduled for the spring of 1951. The furrows were plowed on the contour at 6-foot intervals using a jeep and fire plow with the disks removed. One man completed the furrowing in three hours. Machine seeding of such furrows is inexpensive and has shown promise in preliminary studies. If this procedure proves successful, it will greatly reduce the cost of artificial regeneration of old fields suitable for seeding. These studies are being conducted in cooperation with the Shawnee National Forest.

Seed sources.--Two new studies of geographic seed sources were added to those started in southern Illinois in 1948. In one study, conducted in cooperation with the Tennessee Valley Authority, seedlings of loblolly pine from nine geographic sources were planted in experimental blocks on the Kaskaskia Experimental Forest. At the end of the first growing season the groups of seedlings showed marked differences in both survival and growth.

In another study, redcedar seeds collected two years ago from eight widely scattered geographic sources were sown in the Mason County, Illinois, State Nursery. A work plan has been prepared and plots laid out for testing the resulting seedlings.

Hybrid pines.--A supply of several different hybrid pine seeds was obtained from the California Station and planted in the Union County, Illinois, State Nursery. A working plan has been written and experimental plots laid out for a study of the survival and growth of this hybrid stock.

Reinforcement planting.--In the spring of 1948 we started a study to explore the possibilities of converting poor oak-hickory stands in southern Illinois to mixed stands of shortleaf pine, Eastern redcedar, and the natural hardwoods. These plantings were released from competing hardwood brush in the spring of 1950. In some cases very little release was needed. The conifers, all of which were planted in openings in the hardwood overstory, showed good survival and growth. The results of this study will serve as a guide to large-scale reinforcement plantings on several oak-hickory compartments of the Kaskaskia Experimental Forest.

Coniferous plantations in Iowa.--Studies were started in 1949 to test the suitability of various coniferous species to the soil and climatic conditions of two widely separated locations in Iowa. In the spring of 1950 various additions were made to the original experiments.

In one study, established on the Paint Creek Experimental Forest in northeastern Iowa, the original planting consisted of 16 species in replicated plots of 80 trees each. The planting was on a northeastern exposure of Fayette soil. Survival at the end of the second growing season averaged 92.8 percent. In the spring of 1950 this study was duplicated on a southwestern exposure. In addition, twelve new species were added to the study: Scotch, Table-Mountain, and Japanese red pines; Sitka spruce; European and Japanese larches; balsam and noble fir; Port-Orford-cedar; Western redcedar; one-seed juniper, and Eastern hemlock. The new plantings averaged 80.6 percent survival at the end of the first season. Since many of these species are planted far outside their natural range, some winter damage may be expected.

The second major planting experiment was established in the loessal hills of Monona County about 25 miles east of the Missouri River in western Iowa. This study is carried on in cooperation with the Iowa Agricultural Experiment Station. The original planting included 19 different coniferous species. Survival at the end of the second season averaged 86.7 percent. In the spring of 1950, four new species were added to the original 19: Table-Mountain and Japanese red pines, one-seed juniper, and Japanese larch. First year survival averaged 80.6 percent for these species.

Ground preparation and methods of planting.--In 1949 three 1.5-acre blocks were planted to white pine and three to yellow poplar to compare several planting methods in combination with various ground-preparation treatments. Our purpose was to discover the cheapest combinations that would give satisfactory survival and growth for trees planted in old fields in southeastern Ohio.

Hand methods using the planting bar and mattock, and a machine method using the Muskingum modification of the Lowther planter were tested in five areas prepared as follows: (1) no ground preparation; (2) scalps, where the sod was removed from 2- by 2-foot spots; (3) single furrows which were plowed with a single-bottom plow; (4) double furrows which were plowed with a double-bottom plow; (5) rips made with a single-toothed shale (or road) ripper to a depth of 24 inches. Planting methods and treatments were

Table 7.--Survival of trees planted on two old fields in Ohio by species, method of ground preparation, and method of planting

Tests	Harrison County First-year survival		Muskingum County Second-year survival	
	White pine	Red pine	White pine	Yellow poplar
	Percent			
Ground preparation				
No preparation	94	93	93	97
Scalps	99	99	92	95
Single furrow	100	95	98	98
Double furrow	98	99	87	95
Rips	98	99	95	98
Planting				
Bar	97	96	87	95
Mattock	99	98	94	97
Machine	97	97	97	98

Table 8.--Relative cost ratings for planting by method of ground preparation and method of planting[1/]

Planting method	Method of ground preparation				
	No Preparation	Double furrow	Single furrow	Rips	Scalps
Machine	1[2/]	2	3[3/]	5	6
Bar-slit	4	7	8	10	11[4/]
Mattock side-hole	9	12	13	14	15

1/ Basis: Costs for all plantings listed in table 6.
2/ Cheapest combination tested.
3/ Easier planting by hand and by machine on the top of the double furrow slice than bottom of single furrow accounts for lower cost.
4/ Almost four times the cost of planting by machine using no ground preparation.

randomly assigned to the plots for each species. Trees were planted in the center of each scalp, in the bottom of the single furrows, on the "furrow slices" created by the double-bottom plow, and in the cuts made with the ripper.

In the fall of 1950, the end of the second growing season, there were no significant differences in survival between methods of planting or ground treatment. The results using the cheapest combination (machine planting on nonprepared ground) were as good as those obtained with any of the other combinations. The results of this study are summarized in tables 7 and 8. The plantings in this test are too young to make growth comparisons.

RANGE RESEARCH

Northern Ozark Branch

During 1950 range research was focused on: (1) gathering information for and writing a range problem analysis, (2) planning and initiating studies on the chemical control of woody plants, (3) determining the success of national forest range reseeding trials, and (4) taking initial vegetation data on a number of deer and livestock exclosures.

Problem Analysis

The range problem analysis will soon be ready for Station review. The general conclusion of the analysis is that the only place for permanent range livestock production of any importance in the Ozarks is on areas where the soil is practically untillable or is too shallow to grow good timber.

Small land holdings, low carrying capacities, and the very difficult job of keeping trees and sprouts from crowding out herbaceous vegetation make range operations almost impossible in those sections of the Ozarks where good commercial timber can be grown. If forest lands are cleared and kept open, dense stands of native grasses and legumes eventually cover the ground, but our experience shows that such forage will rarely pay the cost of clearing and keeping the land brush-free. Also, since rainfall is relatively high, tillable areas will usually return more profit if developed into high-yielding, improved pasture than if left in native forage.

Most of the poor timber in the Ozarks is either on rough, dry, rocky sites characterized by narrow ridges and steep slopes or on the so-called post oak flats. On the "rough," poor timber lands, only the narrow ridge tops and stream bottoms could be considered accessible to cattle under good range management. The problems which would have to be overcome to distribute cattle properly over these narrow, irregular peninsulas of usable forage are too great to justify clearing these rough lands for forage production.

The post oak flats, on the other hand, are fairly level and stone-free and occur in relatively large, continuous tracts. If converted from forest to forage, they could readily be used by range livestock. However, there is some question as to whether these lands, if converted, should be used for range (that is, to produce native forage) or be developed into improved tame pastures.

The most promising areas for future range livestock production in the Ozarks are the "glades." The glades cover about 350,000 acres of rough, shallow-soiled, rocky, limestone land in the southwestern Ozarks where cultivation is impractical, where the only timber products are red-cedar posts, and where little bluestem, big bluestem, and associated

prairie grasses are the natural cover. Perhaps the greatest problems on the glades have to do with the palatability and nutritive value of the native forage. As rapidly as we complete projects dealing with the overall Ozark range situation, more effort will be shifted to the glades.

Sprout Control

A major range maintenance job in the Ozarks is keeping sprouts and trees from crowding out the grass. Although repeated burning and severe goat browsing have been used with some success to control woody vegetation, these practices have undesirable effects that make their use questionable. Since the woody plant control problem is so widespread on Ozark range land, we decided that some work on the chemical control of brush and trees could properly begin before the range problem analysis was completed. Consequently, several exploratory tests and two formal sprout-control studies were started this year. We also prepared a paper entitled Problems in Control of Woody Vegetation in Pasture Development, which was published in the Proceedings of the Weed and Sprout Control Short Course, March 1950, by the Missouri Agricultural Experiment Station.

The sassafras and persimmon sprouting study was an exploratory test in which both amine and ester forms of 2,4-D and 2,4,5-T were applied to the lower 12 inches of the trunks of sapling-size sassafras and persimmon. All solutions included 2.0 percent of the herbicide on an acid-equivalent basis. We applied the herbicides both in kerosene and in an emulsion of 1 part kerosene and 4 parts water thickened to the consistency of a thin paste with wheat flour. The pastes were applied with a paint brush; the oil solutions with a sprayer. The rate of application was 1 quart per 10 trees. Treatments were applied on June 1 and 2 and the first observation was made on September 28.

Our first observations indicate that (1) sassafras is much more susceptible to 2,4-D and 2,4,5-T than is persimmon, (2) sassafras is almost as susceptible to 2,4-D as to 2,4,5-T, (3) on sassafras the ester and amine forms of 2,4-D and 2,4,5-T are about equally effective, and (4) kerosene solutions are more effective than oil-water emulsions.

All kerosene solutions of 2,4-D and 2,4,5-T killed the sassafras tops. Persimmon was resistant to the amine forms of both 2,4-D and 2,4,5-T. The esters of both compounds are more effective on persimmon if applied in kerosene than if applied in an emulsion, and the esters of 2,4,5-T are markedly more effective than the esters of 2,4-D. However. even the 2,4,5-T esters in kerosene killed only 60 percent of the top wood of persimmon.

In the first formal study, the Sprout Spraying Study, reproduction-size sprouts were sprayed in mid-June with water solutions of the following herbicides: 10.7, 19.4, and 32.4 percent solutions of ammate and 0.2, 0.5, and 1.0 percent solutions (acid-equivalent basis) of (1) 2,4-D butyl ester, (2) 2,4,5-T isopropyl ester, (3) 2,4,5-T propylene glycol butyl ether

esters, (4) 2,4,5-T amine, and (5) a 50-50 mixture of the propylene glycol butyl ether esters of 2,4-D and 2,4,5-T. Each mixture was applied in the early morning, at midday, and in the late afternoon. In September we made detailed post-treatment observations including stem kill, stem injury, leaf kill, leaf fall, and the number and length of basal and stem sprouts on each sprout clump.

Sassafras and persimmon were much more susceptible to ammate than were oak and hickory. However, there were no apparent differences between the responses of different species of oak and hickory to ammate.

Ammate, even at the 10.7 percent concentration, caused more stem injury and stem kill than any of the growth-regulator herbicides on all species of oak and hickory, but the hormones were fully as effective as ammate on sassafras and sumac.

Both 2,4-D and 2,4,5-T caused more stem injury on post oak than on blackjack oak, although both species seemed more susceptible than black oak, white oak, or hickory.

Sassafras and sumac were especially susceptible to all forms and concentrations of 2,4-D and 2,4,5-T with stem and leaf kills approaching 100 percent for all mixtures and concentrations.

Stem injury on post oak and blackjack oak by all herbicides at the lowest concentration was least in the morning, intermediate at noon, and highest in the late afternoon, but time of day had little apparent influence at higher concentrations or on other species.

Stem injury on the oaks and on hickory increased more sharply when the concentration of herbicide was raised from the low to the intermediate concentration than when raised from the intermediate to the high concentration.

The percentage of the oaks and of hickory which apparently were dead (top dead and no sprouts) was very low for all treatments, but apparent kill was 75 to 100 percent on sassafras and sumac.

The percentage of clumps which had sprouted by mid-September was too low to justify comparison between treatments. Final data on sprouting and percent kill will not be available until after one or two more growing seasons have passed.

Sapling Sprouting Study

Our other formal experiment involves the use of the amine ester forms of 2,4,5-T at concentrations of 1.0 and 2.0 percent (acid-equivalent) applied in oil and in a flour-thickened oil-water emulsion to the lower 12 inches of trunk in September, December, and June. Three low-cut stump applications of ammate (that is, ammate crystals, 32.4 percent water

solution, and flour-thickened 32.4 percent water solution) to post oak are also scheduled for each treatment date. The September and December treatments have been completed. The June treatments are scheduled for June 1951, and the first complete set of observations will be made in September 1951.

Range Reseeding

Most range reseeding by the national forests has been done by plowing or disking, applying lime and fertilizer, and seeding to Korean lespedeza and a mixture of tame pasture grasses. Pasture grasses which have shown promise include orchardgrass, tall fescue, redtop, and smooth brome. These seedings have been made on old fields which were already cleared and level enough to be plowed, drilled, and mowed. Clippings from one orchardgrass-Korean lespedeza pasture during the past two years show that about 1,000 pounds of orchardgrass per acre is produced by June 1 and another 1,500 to 2,000 pounds by late October. Korean lespedeza produces practically nothing before June 1 but makes about 1,000 pounds of herbage between June 1 and fall. Pasture of this type carried one 800-pound steer per two acres from June 1 to August 1, 1950, without overgrazing. However, one steer per two acres proved to be excessive stocking for late summer and fall.

Another possibility is planting native prairie species on old fields. Big bluestem, Indiangrass, and other prairie species have been planted on old fields protected from grazing and good stands have resulted. However, the palatability and nutritive value of these artificially established stands of native grasses have not been investigated. Perhaps native species can be established and successfully maintained with less cash outlay for lime, fertilizer, and tillage than is required for tame pasture grasses.

Exclosures

We spent two field weeks in 1950 taking vegetation records and photographs inside and outside of two sets of deer and livestock exclosures put up in 1946 and 1947 as a joint undertaking of the U. S. Forest Service, the Missouri Conservation Commission, and the Fish and Wildlife Service. We studied the effects on the vegetation of excluding deer and livestock, and also observed the effects of releasing herbaceous vegetation by cutting or girdling the larger trees. Remeasurements are planned every two to five years. Administrative costs and responsibilities in connection with the project are shared by the Fish and Wildlife Service, the Missouri Conservation Commission, and the Clark and Mark Twain National Forests.

RESEARCH CENTER DEVELOPMENT

In addition to the results reported under the preceding subject-matter headings, we have made progress in developing experimental areas, adding equipment and physical improvements, and otherwise bettering facilities and advancing the over-all research programs of the Branch Stations.

Ames

About a thousand persons attended the Northeast Iowa Forestry Field Day on May 5, 1950. The group met at the Paint Creek Experimental Forest where the forestry and research programs of the Extension Service, the State Conservation Commission, and the Forest Service were presented. Demonstrations included tree planting by hand and by machine, the use of power saws and other logging equipment, fire-fighting methods and tools, and sawing and piling of native lumber. Unfortunately, rain and winds reaching 35 to 40 miles per hour kept the group from visiting the farm forestry tract in the afternoon.

We made arrangements with the Amana Society for conducting thinning studies in the 53-year-old white pine plantation on Society land in central Iowa. Progress was made in harvesting the trees marked for cutting. However, because of the way in which the harvesting was done--on the basis of the Society's needs--it was not possible to complete the job during 1950.

A hydraulic lift, to be attached to a tractor, and certain other items were added to the equipment at the Paint Creek Experimental Forest.

Buckeye

Drafts of the over-all Branch Station problem analysis and of a forest influences problem analysis were completed during 1950 and distributed for in-Service review.

We made a reconnaissance to locate an area suitable for development as an experimental and demonstration watershed. The area tentatively selected consists of seven to eight sections in the Jackson Run and Irish Run watersheds, Washington County, Ohio, within the Little Muskingum Purchase Unit. The supervisor of the Wayne-Hoosier National Forest is giving high priority to the acquisition of privately owned lands in the area.

We also continued our reconnaissance of the Ironton District of the Wayne-Hoosier National Forest in an effort to find an area suitable for development as an experimental forest.

Several major items of laboratory equipment needed for research in soils and plant physiology were added to our laboratory at the Athens headquarters. So far as present needs are concerned, the laboratory is now completely equipped.

A new crawler tractor and other logging equipment were also acquired during the year.

Carbondale

During the year we developed a new record system, including summary forms, for the comprehensive management study on the Kaskaskia Experimental Forest. The forms provide for detailed data on existing stands, volume of products removed by class of product and grade, value of products removed, management costs, and production costs by compartments. All records for this study were brought up to date.

Because markets for sawlogs in the vicinity of the experimental forest are limited, progress on the forest management studies and other studies that require cutting and disposing of sawlogs have been hampered. To help solve this perplexing marketing and utilization problem, we obtained a medium-size portable sawmill late in 1950. This mill will also be used to demonstrate to local operators good sawmilling practices, mill and equipment lay-out, and lumber grading, sorting, and stacking. There is a definite need for demonstrations of this kind in southern Illinois and neighboring areas.

We made some progress in completing the road system for the experimental forest. During the year, 1.9 miles of primary road were constructed.

A new crawler tractor and other smaller items of logging equipment were acquired during the year.

In cooperation with the R-9 Division of Engineering, plans were prepared for the proposed garage and workshop for the experimental forest.

Northern Ozark

The Sinkin Experimental Forest, in the Clark National Forest, was formally approved and set aside for research during the year. The experimental forest consists of two major units. The Bunker Unit, located on the Salem Ranger District, contains about 4,116 acres. The Cedar Bluff Unit, located on the Winona District, contains about 5,680 acres. Both units are in the oak-pine forest type.

During 1950 the first draft of the Branch Station problem analysis, and the recommended program based upon it, were prepared and reviewed at an in-Service conference. The problem analysis and research program were also presented to and discussed with the Branch Station Advisory Committee. Comments and suggestions received during these conferences provide a basis for the final revision of the problem analysis and research program.

Approximately 400 acres on the Cedar Bluff Unit of the Sinkin Experimental Forest were given an improvement treatment under supervision of the Clark National Forest. This work consisted chiefly of girdling cull trees.

Forest Survey

Missouri.--The analytical report on the forest situation in Missouri was published in December 1949, but was not released until June 1950. It was called Forest Resources and Industries of Missouri, Research Bulletin No. 452 of the University of Missouri College of Agriculture and the Agricultural Experiment Station. Publication of this report completed the initial Forest Survey work in Missouri.

Illinois.--The first draft of the analytical Survey report for Illinois was completed and at year's end the first revision was almost finished.

Kentucky.--Inventory field work in Kentucky was discontinued in December 1949 because we had no aerial photographs of eight southeastern counties. The Production and Marketing Administration and the State of Kentucky had made arrangements to complete the photo coverage of those counties. Because of unfavorable weather for aerial photography, however, we did not get these photos until December 1950 and early January 1951, so no field plots were measured in Kentucky during 1950.

We measured two hundred trees in the field and used the data in preparing volume tables. Form-class analyses were made of sample trees and volume tables were read from the basic form-class tables. We prepared volume curves and tables for pole-size trees and volume tables for tops of softwood species. Forest-area and timber-volume statistics were compiled for all survey units in the state except for the southeastern eight counties. Forest Survey Releases No. 8, Forest Statistics of Western Kentucky, and No. 9, Forest Statistics of Central Kentucky, were issued and give forest-area and timber-volume information for these areas.

The compilations necessary to find the volume of timber cut in Kentucky in 1948 were completed.

We computed growth rates in cubic feet and board feet for all but the eight southeastern counties after completing analyses of radial growth and bark thickness.

Indiana.--Inventory field work in Indiana was completed in November 1950. During the year, we made a survey to determine the volume of Indiana timber cut in 1949. Field work was completed and preliminary computations of the results were made. For the first time we tried to estimate drain by a tally of stumps of trees cut for commercial use on inventory field plots during the preceding 12 months. Later, we will estimate the volume of the cut trees on each Survey field plot from the net volume tables by converting stump diameter to diameter breast height using average merchantable lengths. These plot volumes of cut trees will then be "blown-up" to determine the total cut of merchantable timber in the state. After comparing timber drain for Indiana by the conventional method with that obtained by this new method, we may find it desirable to change our way of determining timber drain.

Lumber production estimates were obtained in cooperation with the U. S. Bureau of the Census. By advance planning and by dividing the field work, the Census obtained additional data with which to strengthen its regional lumber-production estimates, and the Station obtained a reliable state estimate at a lower cost than if it had done the entire job. There was no duplication of effort.

Production figures for fuelwood, fence posts, and miscellaneous farm timbers were obtained in cooperation with the Indiana Extension Forester and the State Forester, who detailed men for some of the field work. By interviewing farmers and other woodland owners, we obtained production reports in sample areas randomly selected from the Master Sample of Agriculture. Station staff members wrote letters and conducted interviews to get production reports on other products.

Special drain studies were made in Indiana to obtain reliable estimates of the following four factors:

1. The average difference in board-foot volume between lumber production as reported by mill operators and International 1/4-inch log scale of the logs sawed.

2. The percentage of utilized sawlog volume coming from trees of less than saw-timber size.

3. The percentage of the sawlog volume cut that is not used for manufactured products.

4. The average ratio of volume in tops and limbs to that in sawlogs.

The over-run factor obtained from the first study was approximately 15 percent, indicating greater utilization at the mill than was found in Missouri and Illinois. The volume of pole-timber trees cut for sawlogs was negligible.

Approximately 16 percent of the net board-foot volume of trees cut for sawlogs is left in the woods. Most of this volume is in top logs that are small and knotty. Under present cost and market conditions, utilization in the woods is considerably below the standards used in the Survey, which included fairly clear and straight material up to an 8-inch top.

Of the trees cut for sawed products and veneer, the volume in tops and limbs to a 4-inch diameter was found to be about 37 cubic feet per thousand board feet of logs.

We transferred the sample-tree information from field tally sheets to tabulating machine cards and started to make form-class analyses for determining volume tables.

Ohio.--Several conferences were held with forestry leaders in the state to develop a mutually satisfactory way to carry on Survey field work in this state. Because of unfavorable flying weather during much of the 1950 flying season, only about one-third of the state was covered with acceptable aerial photographs. Most of the computed counties are in the northwestern part of the state; a few are scattered through the remainder.

General.--During the year several key Survey men were assigned to special projects. Karl E. Moessner served from April 1 to July 7 as a forestry specialist to the U. S. Army to make a land-use and timber-resource survey of the island of Okinawa. By using aerial photographs available to the Army and a limited amount of ground inspection, he was able to complete the work in three months.

Maxwell E. Becker was detailed to Washington during February, March, and April to assist in preparing a report on the forest resources of China. This report is being prepared by the Foreign Forestry Unit of the Division of Forest Economics in our Washington Office. From July through September he was on active military duty with the Eastern Branch, Intelligence Division, Office of the Assistant Chief of Staff, Washington, D. C., as a Korean specialist.

David B. King was assigned to our Washington Office from April 17 to May 19 to prepare a report on the Ohio River Basin as a part of an over-all report prepared by the Forest Service for the President's Water Resource Policy Commission (see p. 3). Again in December he was called to Washington to assist in preparing a special industrial resource report on the requirements, production, and supply of wooden pallets.

On July 1, E. V. Roberts left this Station to become Chief of the Division of Forest Economics at the California Forest and Range Experiment Station.

James T. Morgan prepared a report describing present types of stationary wood chippers and some modifications and new developments that may prove useful in processing low-quality and waste wood. It was presented at the Northeastern Wood Utilization Council's Conference on Chipped Wood, and will be published in the Council's Bulletin.

Marketing Farm Woodland Products

Missouri.--In 1950 a report, Marketing Farm Woodland Products in the Missouri Ozarks, was published as Station Technical Paper No. 116. This report describes forest products marketing in six northern Ozark counties. It gives information on kinds of products sold, prices paid, location of markets, and marketing methods. To improve the present marketing situation, the report suggests additional efforts by both public and private agencies to inform woodland owners and timber operators of the best markets and marketing methods, more research to solve marketing problems, judicious industrial expansion, and good forest management.

In June we officially started a new project--a study of the markets for pine timber and of the size of the pine resource in the Missouri Ozarks. The study is being conducted in cooperation with the Missouri Division of Resources and Development and with the assistance of personnel from the Northern Ozark Branch Station. Field work on both phases of the study is under way.

We have completed about 40 percent of the field plot work necessary to determine the pine area, volume, and quality in six eastern Ozark counties. All of the winter aerial photos in the area have been studied. Our photo interpreters have examined over 9,000 forest plots on these photos under stereoscopes and have classified them as to the percentage of pine on each plot. Preliminary pine-cover maps showing the general location of pine, pine-oak, oak-pine, and oak timber stands have been prepared from the aerial photos for four of the six counties. The maps will later be corrected by on-the-ground examinations.

Several operators harvesting pine timber were interviewed and some case studies of pine timber logging operations were made to get information on the costs and returns involved in harvesting various products. These and later field interviews and studies will give us information on the most profitable products that can be marketed from various sizes and qualities of pine timber.

We personally interviewed about 175 farmers in 23 northwest Missouri counties. These interviews were made to find out what kinds of posts are now being used and what the potential market is for treated pine posts in this and similar areas. Several retail lumberyard managers in northwest Missouri were also questioned about the kind and number of posts they sell.

Illinois.--A List of Wood-Using Markets Available to Southern Illinois was completed, duplicated, and distributed in February to state and federal employees of the Central States region and to a few cooperators representing industry. Many corrections and additions have been made to this list since its distribution, and we are attempting to keep it current.

We completed field and office work on the project set up to find out whether it is feasible and desirable to expand the markets for wood products from Southern Illinois. The first draft of a technical report on this project has been completed and is entitled Marketing the Farm Forest Products of Southern Illinois. Some of the findings and recommendations of this report are:

1. The forests of Southern Illinois can contribute a greater share of the income of this region (a) through better marketing of woodland products, (b) through increased processing of rough lumber into finished lumber and other finished wood products, and ultimately, (c) through a considerably increased annual timber cut made possible through greater protection from fire and grazing and through improved woodland-management practices.

2. Only 20 percent of the existing 2.6 billion board feet of saw timber in Southern Illinois is of high quality preferred by most local operators.

3. Though the forests grew 103.5 million board feet of saw timber in 1947 while only 56.9 million board feet were cut, the gain was mainly in low-quality timber which is difficult to market.

4. Much of the existing large volume of low-quality timber must be removed from forest areas to make room for growth of high-quality timber.

5. To improve the situation through better marketing: (a) expand all markets which use low-quality timber, (b) expand local processing of lumber and local wood remanufacturing, (c) develop new marketing facilities for primary wood products and for lumber, (d) provide more marketing information for the woodland owners, secondary wood users, and wood remanufacturers, (e) provide greater service to farmers through research, extension, and technical assistance, and (f) encourage permanent wood markets through a dependable production of woodland products.

A proposal for a continuing marketing-utilization project for Southern Illinois was prepared and submitted to the Washington Office for approval. It has been approved in principle and work is under way. In general, it will market marked timber from the woodlands of cooperating farmers and from the farm woodlots and management compartments of the Kaskaskia Experimental Forest. The objective will be (a) to develop marketing procedures that will enable farmers to market their woodland products more profitably, and (b) to show how markets can be developed for low-quality logs and bolts which cannot now be marketed from farm woodlands at a profit.

We also cooperated with a committee appointed by the Governor of Illinois to consider plans for developing the industrial potential of Southern Illinois. A report, Suggested Expansion of Southern Illinois' Forest Industries, was prepared and submitted to this committee. It contained preliminary data and findings of the marketing project already under way. These data and findings will be covered more fully in the technical report, Marketing the Farm Forest Products of Southern Illinois mentioned above.

FOREST UTILIZATION SERVICE

Primary Producers

Because of the size of the job involved, we have long recognized that it is better to work as much as possible through organizational channels rather than through contacts with individual establishments. This approach is especially important in the field of the primary wood-using industries. For example, there are over 11,000 producing sawmills in the region; 96 percent of them saw less than one million board feet per year. Collectively, however, these small mills account for over 80 percent of all lumber produced in the Central States. It is this type and size of operation which can benefit most from the FUS program.

One of our major objectives has been to reach a greater percentage of these primary producers. Established organizations such as the Extension Service, Soil Conservation Districts, the Farm Forestry programs, and state-wide and industry-wide organizations of primary forest industries offer the best opportunities for FUS to operate at the "wholesale" rather than the "retail" level. Our working relationships with these organizations at the state and area levels have been improved and expanded during the past year.

Sawmill Short Course

Typical of this type of approach is the short course in small sawmill operation which we held exclusively to train state extension foresters and their assistants. About 25 men from the 12 states in the North Central Extension Service Region took part in a 5-day meeting at the University of Illinois Experimental Farm near Oregon, Illinois. FUS in cooperation with the University, the Forest Products Laboratory, and several of the larger equipment manufacturers, conducted this course, planned specifically to carry proper techniques and new developments in small sawmill practices to small rural industries.

We strengthened cooperative relationships with state and regional lumber associations and developed several mutually beneficial projects. Our contacts during the past year with the Indiana Hardwood Lumbermans Association, the Appalachian Hardwood Manufacturers Incorporated, the American Walnut Manufacturers Association, and the Industry Division of the Ohio Forestry Association have been especially profitable.

Logging and Sawmilling Equipment Demonstrations

Also in the field of "wholesaling" information are the annual logging and sawmilling equipment demonstrations sponsored jointly by FUS and extension foresters. These shows have been held in three widely separated locations in the region and are being recognized as valuable meeting places for timber operators and equipment manufacturers. At these shows we have emphasized equipment designed for or readily adapted

to the selective harvesting of farm and other small timber holdings. The 1950 show was held in south central Indiana and attracted approximately 3,000 persons during the two days of the event. Some 35 different equipment manufacturers demonstrated selected items from their logging and sawmilling lines. Of special interest were the exhibits of home-made logging devices including sulkies and self-loading trucks brought in by small sawmill operators and entered in a special contest for devices of this type.

Plant Visits

Our top priority job in the field of remanufacture and processing of primary forest products was visiting a variety of plants in all parts of the region to get a fair cross section of industry's wood-use developments and problems. Field contacts were made by FUS with officials of over 150 factories and mills during the year; 98 percent of them requested and received technical information on many phases of forest products research. Kinds of technical advice most frequently requested concerned lumber dry-kiln schedules and conditioning treatments, reduction of air-seasoning degrade, moisture-content control in the factory, wood bending, water-repellent and preservative treatments, gluing procedures and types of glues, machining of wood, possibilities of making hardboard from plant waste, and applications for modified woods. Some unusual problems involving premature failure or deterioration of wood in use were referred to the U. S. Forest Products Laboratory for advice by research specialists.

Wood Sugars

Studies of the livestock feeding value of sugars obtained from chemical conversion of wood waste were started through the efforts of FUS at two experiment stations operated by the University of Missouri, and at one experimental farm administered by the University of Illinois. In each case, grass silage to be fed to cattle next spring (1951) was preserved with wood-sugar molasses. An experiment in which wood molasses will be fed directly as a carbohydrate supplement with mixed grain and concentrates is also scheduled. Arrangements were made by FUS to supply the molasses for these experiments. Nine tons were obtained from the TVA pilot plant in Alabama and one ton from the Forest Products Laboratory.

Some successful small-scale feeding tests with wood molasses or wood-sugar yeast were conducted by three Central States commercial producers of livestock feeds.

Growth-Quality Studies

Opportunities for growth-quality studies in coordination with silvicultural and forest management research were appraised on a field trip by FUS and the Chief of the Forest Products Laboratory Division of Silvicultural Relations. We made observations on areas served by the

Station's Northern Ozark and Carbondale Branches in company with branch staff men. The purpose of these studies is to determine the effects of different silvicultural treatments on tree quality. Several lines of study were proposed for future consideration when preparing research plans for the branches.

Other Activities

Miscellaneous activities of FUS included (1) preliminary field work for another gluing clinic, (2) gathering information on charcoal producers in the Central States for the Forest Products Laboratory, (3) advising the Cape Girardeau, Missouri, Chamber of Commerce on how to increase industrial developments in the utilization of timber in that vicinity, (4) cooperating with Forest Products Laboratory engineers in a survey of low-cost housing performance they are making for the Housing and Home Finance Agency, (5) cooperating with a Forest Products Laboratory specialist in a study of tension wood (abnormal growth structure) in Illinois cottonwood timber, (6) assisting with field work and editing in the Forest Service Nation-wide survey of wood used in manufacture, and (7) serving on special assignments concerned with defense-preparation studies of military lumber requirements and industry's needs for primary logging equipment.

PLANS FOR 1951

In making our plans for 1951 we have assumed that defense activities will be stepped up, but that the Nation will not become involved in a major war. The present national emergency, even if it does not become more critical, is certain to affect forest research. More personnel will be lost to the armed forces, and we will have to adjust our research program to shift manpower to problems directly connected with national defense. Certain desirable new studies we originally scheduled for 1951 may have to be deferred. However, in view of the importance of forests to the Nation's economy and war potential, we will make every effort to continue research aimed at increasing efficiency in protecting and managing our forests and in harvesting, utilizing, marketing, and processing the products from them.

At the present time we know of and have provided for two new defense jobs we will be called upon to help with next year. The National Security Resources Board and the National Production Authority have asked the Forest Service to make a Nation-wide survey of labor, equipment, and supply requirements of the logging industry. The Central States Station will handle this survey within its territory. At the request of the Corps of Engineers, the Forest Service is also making a study of the lumber requirement and procurement problems of major military installations throughout the Nation. This study is being conducted by the Forest Products Laboratory, and it is expected that our FUS unit will handle the work in the Central States Station territory.

As defense activities are stepped up, the Station will undoubtedly be called upon to make more special studies of this kind. At present it is impossible to predict the size or nature of the Station's defense work load for next year. The research plans presented on the following pages are based on our best estimate of the defense work we will be called upon to do and may, of course, be changed to meet changing conditions.

FOREST INFLUENCES

Flood Control Surveys

Reports covering the Upper Mississippi and East Fork of White-Patoka will be revised to conform with Washington Office recommendations. It is expected that the surveys of the Cuyahoga, Kentucky, Licking, and Red River of the North will be completed during 1951.

Forest Influences Research

Our preliminary studies of the effects of soil properties and land use upon the movement of water in the soil have paved the way for more ambitious research in this field. Plans for the Buckeye Branch, where all our influences research is conducted, call for the construction of several small stations to measure precipitation, runoff, and subsurface movement of water. These stations will be semipermanent (expected life, two to three years), employ very simple measuring devices, and occupy small land areas (less than one square chain). Simple experimental equipment will be used so that we can repeat the experiments easily. This work will require about four years.

Research on the factors influencing the growth and decay of the root systems of forest trees will be continued and expanded. We plan to develop simple, quick, and inexpensive methods for determining the extent and distribution of living roots and the location of former root systems. The use of the Athens soil sampler and smoke bombs show promise in this respect.

The following manuscripts will be completed and published during the year: The Concentration of Roots in the White Oak Forests of Southeastern Ohio, and A Relation Between Tree Roots and Percolation in the Forest Soils of Southeastern Ohio. In addition, a manuscript entitled The Effect of Certain Soil Properties Upon the Movement and Storage of Water in Some Soils of Southeastern Ohio will be revised and possibly published during 1951.

FOREST MANAGEMENT

Most management research is carried on by the Branch Stations. The 1951 plans for management studies are given below under the heading of the field unit with primary responsibility. There are, however, a number of management studies which are best handled by staff men working out of the central office. Plans for these studies are given here.

During 1951 we plan to start a new regional study to determine the effects of the quality of yellow poplar planting stock on survival and growth. Seeds from a single source were sown in 1950 in five different nurseries in three states. The resulting stock will be planted on old fields and spoil banks in Ohio, Indiana, and Illinois. These plots will be checked for survival and growth at the end of the first growing season and periodically thereafter.

The results of another regional study will be summarized in a manuscript entitled Effects of Grading Strip-Mined Lands on the Early Survival and Growth of Forest Plantations. This report should be ready for publication by the end of the year.

In the field of mensuration we plan to continue form-class, volume, and growth analyses between states as forest survey data become available, help field personnel with mensuration problems, and report on basic growth and other data of sufficient interest to justify publication.

Ames

First priority will be given to locating areas in central and southern Iowa suitable for timber management studies. The forest types in these sections of the state are quite different from the forests of northeastern Iowa, where most of our forest management work is now concentrated.

We will cooperate with the Station's Forest Utilization Service, the Iowa Extension Service, and the State Conservation Commission in sponsoring the logging and milling equipment demonstration tentatively scheduled for fall 1951.

Harvesting operations in connection with the white pine thinning study on the Amana Society lands will be completed during the year. The resulting data will be analyzed and a report prepared for publication.

Planting, pruning, and other going studies will be remeasured as needed and otherwise maintained.

We plan to complete the Branch Station problem analysis and submit it for in-Service review and Advisory Committee consideration during 1951.

Buckeye

The Buckeye Branch Station's greatest need is for an experimental forest. Consequently, highest priority will be given to selecting, establishing, and developing a suitable area.

The over-all Branch Station problem analysis will be completed, submitted to, and discussed with the Buckeye Advisory Council.

The following manuscripts will be completed and published during the year: Stand Density as a Factor in the Estimation of White Oak Site Index; The Relation Between Topography, Soil Characteristics, and the Site Index of White Oak in Southeastern Ohio, and Comparative Survivals and Costs of Plantations by Different Methods of Ground Preparation and Planting in Ohio Old Fields. In addition, we will analyze and prepare for publication the results of a study of the rate and quality of natural forest regeneration on old fields in southeastern Ohio.

Our work in spoil-bank reclamation will consist mainly of maintaining going experiments and writing up the results of the older studies. A report on Overburden Analyses and Strip-Mine Conditions in the Northwestern District of the Ohio Coal-Mining Region will be published during the year.

We will continue and expand fundamental research on the nutrition of forest tree species. The results of previous studies will be analyzed and prepared for publication.

Carbondale

Much of our effort will be devoted to continuing the comprehensive management study at the Kaskaskia Experimental Forest. Eight compartments are scheduled for treatment during the year. In addition, we expect to study the extent and character of reproduction on the variously treated compartments.

The "good" farm woodlot will be given its scheduled annual cut. We also plan to start rehabilitating the "poor" farm woodlot, a 24-acre tract of badly deteriorated upland timber on the Kaskaskia Experimental Forest. The first treatment will consist of a heavy harvest and improvement cut.

We will plan the first rehabilitation treatment for the 400-acre management unit on the experimental forest. This tract will be used to study the technique of management plan preparation, and to test systems of management which show promise in plot and compartment studies.

We expect to develop a land-acquisition plan that will assure systematic and orderly acquisition of privately owned nonagricultural lands within the boundaries of the Kaskaskia Experimental Forest which are needed for research purposes and to facilitate administration of the area.

Plans will be made for studies of optimum stocking of upland hardwoods and coniferous plantations, and on the management of older coniferous plantations.

The sawmill at the Kaskaskia Experimental Forest will be set up and put in operation. It will process logs harvested on the Forest, and possibly from private lands in connection with the marketing-utilization study under way in cooperation with Southern Illinois University and other agencies. If funds permit, a bolter saw, planer, and possibly a dry-kiln will be added to the processing equipment at the Experimental Forest. One new heavy-duty truck will be purchased during the year.

The direct-seeding, fall-planting, seed-source, hybrid pine, and reinforcement-planting studies mentioned earlier in this report will be continued and, in some cases, expanded. Two manuscripts will be completed and published during the year: Fall Planting of Pine on Upland Soils of Southern Illinois, and Relative Effects of Some Forest Cover Types on Interplanted Forest Tree Species.

In the field of spoil-bank reclamation, we will explore further the possibilities of producing Christmas trees on stripped lands in southern Illinois, and continue our study of the growth and yield of the older plantations on spoil banks in Indiana. In addition, we plan to start some research on the management of plantations and natural stands on strip-mined lands in Indiana and Illinois. These studies will include investigation of harvesting methods and marketing as well as determination of a silvicultural system that will assure continued production. Two manuscripts, Establishment and Growth of Forest Plantations on Strip-Mined Lands in Indiana and Forest Planting on Strip Coal Lands in Illinois, will be completed and published during the year.

Northern Ozark

The over-all problem analysis and research program for the Northern Ozark Branch will be completed, duplicated, and distributed to local foresters, the Advisory Council, and others interested in forest research in the area. The second annual meeting of the Advisory Council will be held late in the year to review progress and plans for the future.

We expect to make plans for a complete road system for the Bunker Unit of the Sinkin Experimental Forest. A 3,000-acre area in the black-jack oak-post oak forest type on the Rolla District of the Mark Twain National Forest will be examined in more detail to determine its suitability for an experimental forest. If found acceptable, we will start to assemble the information needed for a formal report setting this area aside for research.

Detailed work plans for the pine stocking-thinning study will be completed. The initial thinning will also be finished during the year.

In connection with this and similar studies, volume tables and merchantable-height-over-diameter and form-factor-over-diameter curves will be prepared for second-growth pine trees.

The second-year remeasurement of the walnut pruning study on strip-mined lands in Kansas will be made in the fall. Sprouts that have developed since the initial pruning will be removed from one-half of the study trees.

In the field of spoil-bank reclamation, two manuscripts will be completed during the year: Strip-Mined Lands of the Western Interior Coal Province, to be published by the University of Missouri, and A Progress Report on Forest Planting Experiments on Strip-Mined Lands in the Mid-Continent Coal Field. In addition, we will prepare short summary of this work for publication in the Missouri Log.

During the year we plan to cooperate with the Clark and Mark Twain National Forests in (1) establishing test plantings of Chinese chestnuts in the Missouri Ozarks, and (2) making a survey of their direct seeding of shortleaf pine to determine the effectiveness and feasibility of the method used.

Work on the new cooperative fire-research project will be started early in 1951. Mr. John S. Crosby, now in the Division of Fire Research at the Lake States Station, will be the project leader. He will transfer to the Station early in January, and will be located at Salem, Missouri. Salem, the headquarters of our Sinkin Experimental Forest, is conveniently located in an area of high fire risk.

During the first year, Crosby will devote most of his time to becoming acquainted with local conditions and problems, preparing a problem analysis, and starting a few high-priority studies. Work will be coordinated with the needs of state, federal, and private fire-prevention agencies. Early in the year we plan to hold a meeting with state, federal, and private fire control personnel to obtain their advice and suggestions. Previous discussions have focused attention on the need for studies of fire-danger rating, fire effects, damage appraisal, hazard analysis, fire organization, and use of equipment. However, it will be necessary to assign priorities to assure the most efficient use of our limited personnel and facilities for research in this field.

A draft of the fire-problem analysis, complete with recommended research program, is expected to be ready for in-Service review by October.

RANGE RESEARCH

Northern Ozark

In 1951 we plan to (1) review, revise, and publish the range problem analysis, (2) maintain scheduled work on plant control studies and on the deer and livestock exclosures, (3) prepare and publish an analysis of the influences of species, planting methods, and grazing management on the success of range and pasture reseedings in the Ozarks, and (4) develop plans for a range forage study on the glades.

FOREST ECONOMICS

Forest Survey

Illinois.--The analytical report for the State of Illinois should be completed and possibly published before the end of the year.

Kentucky.--Field work in eight counties in eastern Kentucky will be resumed on January 8 and should be completed by June 30. During the year we expect to complete the computations for forest area and timber volume for these counties and release a state statistical report. We should complete growth calculations and start work on the analytical report for the state.

Indiana.--Compilations of forest-area and timber-volume information should be completed during the year and a state statistical release issued. We expect to complete growth and drain computations and start on the analytical report.

Ohio.--Our present plans call for beginning field work in Ohio in June or July. Unless aerial photographs are available for additional counties early in the year, field work in Ohio will probably be suspended in October or November. At that time it may be necessary to move our field crews to Iowa.

Marketing Farm Woodland Products

Missouri.--We expect to complete field work on the cooperative project. The data will be analyzed and preliminary reports will be prepared.

Illinois.--The list of markets for forest products requires periodic revision and reissuing. Because no other agency has been found to do this, we may expand the list to include a larger marketing area and publish it in some form.

The report Marketing the Farm Forest Products of Southern Illinois will be published by the University of Southern Illinois as a station technical paper.

The integrated marketing-utilization project in Southern Illinois will be developed as a cooperative project with the University of Southern Illinois and other agencies. We will prepare an over-all project work plan. Detailed work plans aimed at improved marketing of specific woodland products will be prepared as needed. We expect to do preliminary marketing work with products from the Kaskaskia Experimental Forest.

FOREST UTILIZATION SERVICE

Defense work will curtail some activities originally planned by FUS for 1951. A study of lumber procurement problems at military installations is already under way. This Nation-wide study, requested by the Corps of Engineers, is centered at the Forest Products Laboratory. FUS units are handling much of the field work. We will also be called upon for substantial assistance in the manpower and equipment survey for the logging industry. Other emergency defense studies are likely to follow. FUS projects which will be given priority in such normal activities as we are able to carry on are:

1. The annual logging and sawmilling equipment demonstration (probably in Iowa).

2. Encouraging wider industry acceptance of Forest Products Laboratory hardwood log grades.

3. Cooperating fully with the Division of Forest Economics and the Carbondale Work Center on the proposed Illinois integrated marketing-utilization project.

4. Conducting another gluing clinic in cooperation with the Forest Products Laboratory.

5. Following up on wood-sugar feeding tests now under way and securing wood molasses or fodder yeast where needed for new experiments.

6. Encouraging better utilization of low-quality hardwood lumber by rough remanufacture at the source and the manufacture of products developed especially to use small clear cuttings.

7. Continuing frequent contacts with wood-using industries giving special attention to correcting faulty practices that create waste and reduce output.

PUBLICATIONS FOR 1950

Becker, Maxwell E. Forest Survey procedures for area and volume determination. Jour. of Forestry 48(7):465-469. 1950.

Brinkman, Kenneth A., and Krajicek, John E. Growth of a white pine plantation in Iowa. Sta. Note No. 61. 1950.

Day, Ralph K. Postwar trends in rural sawmill operation in the Central States. The Lumberman 77(1):61. 1950.

Deitschman, Glenn H. Seedling survival and height growth on graded and ungraded strip-mined land in southern Illinois. Sta. Note No. 62. 1950.

---------- Comparative survival and growth of trees planted under three types of overhead cover on strip-mined land in southern Illinois. Sta. Note No. 63. 1950.

Gaiser, Richard N. Relation between soil characteristics and site index of loblolly pine in the coastal plain region of Virginia and the Carolinas. Jour. of Forestry 48(4):271-275. 1950.

Garver, Raymond D., and Moessner, Karl E. Forest Service use of aerial photographs. Photogrammetric Engin. 15(4):504-517. 1949.

Limstrom, G. A. Overburden analyses and strip-mine conditions in northeastern Ohio. Tech. Paper No. 114. 1950.

---------- Overburden analyses and strip-mine conditions in mideastern Ohio. Tech. Paper No. 117. 1950.

Martin, S. Clark. Problems in control of woody vegetation in pasture development. Weed and Sprout Control Short Course and Conf. Proc., Mo. Univ. Col. of Agr. and Agr. Expt. Sta. Prog. Rpt. 9, pp. 10-11. March, 1950.

Minckler, Leon S. Effect of seed source on height growth of pine seedlings. Jour. of Forestry 48(6):430-431. 1950.

---------- Managing northern hardwoods. Jour. of Forestry 48(9):446-447. 1950.

---------- Characteristics of unmanaged well-stocked stands and interim stocking guides for some upland central hardwood forests. Paper presented at Div. Silvic., Soc. Amer. Foresters' Ann. Meeting, Washington, D. C. 1950.

---------- The professional education of a silviculturist. Paper presented in panel discussion, Div. Silvic., Soc. Amer. Foresters' Ann. Meeting, Washington, D. C. 1950.

Mitchell, Harold L. Publications of the Central States Forest Experiment Station (July 1927 through December 1949). Misc. Release No. 6. 1950.

Moessner, Karl E., Brunson, Forrest D., and Jensen, Chester E. Accuracy of stand-height measurements on air photos. Sta. Note No. 59. 1950.

---------- A stereogram for training in use of parallax wedge. Sta. Note No. 60. 1950.

Morgan, James T. Kentucky lumber production, 1948. Sta. Note No. 58. 1950.

Quigley, Kenneth L. Marketing farm woodland products in the Missouri Ozarks. Tech. Paper No. 116. 1950.

Schnur, G. Luther, and Lane, Richard D. (In cooperation with the Ill. Tech. Forestry Assoc.) Aids for computing tree volumes in Illinois. Tech. Paper No. 115. 1950.

Winters, Robert K. Timber surveyors take to the air. Outdoor Ind. 17(10):4-5. 1950.

---------- The first half century. Fifty years of forestry in the USA. Soc. Amer. Foresters, Washington, D. C. 1950.

PERSONNEL

CENTRAL STATES FOREST EXPERIMENT STATION

1950

ADMINISTRATION

HAROLD L. MITCHELL, Director; Virginia K. Tomlinson, Secretary

HERBERT C. BRADSHAW, Administrative Officer; W. R. Hudgens, Chief Clerk; Mary G. McDonald, Mary L. Posey, Laura C. Sisk, Ruth L. Hughes, Edna M. Stephens, Madge L. Sanders, Virginia D. Simone, Violet J. Powell, Robert W. Smith, John K. Vaughn, James R. Rice, James R. Davis, Arnold Ross

FOREST ECONOMICS

ROBERT K. WINTERS, Chief; Edith D. Clark, Secretary

Forest Survey

Photo Interpretation--
Karl E. Moessner, Forrest D. Brunson, Chester E. Jensen

Field Inventory--
Maxwell E. Becker, Edwin F. Youngblood, George N. Semmens, Thaddeus A. Harrington, Walter B. Metcalf

Growth and Statistical Procedures--
G. Luther Schnur

Commodity Drain--
James T. Morgan

Computing--
Lake F. Compton, Margaret K. Peirsol, Mary L. Sterner

Forest Resources Analysis--
David B. King

Farm Woodland Marketing Studies

Robert K. Winters, Kenneth L. Quigley, O. Keith Hutchison

FOREST MANAGEMENT

ARTHUR G. CHAPMAN, Chief; Alberta M. Hiatt, Secretary

Mensuration	Silviculture
G. Luther Schnur	G. A. Limstrom

FOREST UTILIZATION SERVICE

_____, Chief

Primary Forest Industries	Secondary Forest Industries
Ralph K. Day	Marsden R. Brundage

FLOOD CONTROL

HAROLD F. MOREY, Subject-matter Specialist; John T. Auten, Theodore J. Schmitt, Evelyn E. Vukovich

BRANCH STATIONS

CARBONDALE BRANCH, Post Office Building, Carbondale, Illinois

Richard D. Lane, Work Center Leader; Leon S. Minckler, Glen H. Deitschman, Cleo Caraway

Kaskaskia Experimental Forest, Elizabethtown, Illinois

Donald L. Fassnacht, B. A. Roach

AMES BRANCH, c/o Forestry Department, Iowa State College, Ames, Iowa

E. Garth Champagne, Work Center Leader; Kenneth A. Brinkman, Clara C. Mikkelsen

Paint Creek Experimental Forest, McGregor, Iowa

John E. Krajicek

BUCKEYE BRANCH, c/o Ohio University, Athens, Ohio

_____, Work Center Leader; Robert W. Merz, Richard N. Gaiser, Raymond F. Finn, William T. Plass, Margaret E. Pierson

NORTHERN OZARK BRANCH, c/o University of Missouri, Columbia, Missouri

Franklin G. Liming, Work Center Leader; S. Clark Martin, Floyd B. Clark, Martha L. Wiggins

Sinkin Experimental Forest, c/o U. S. Forest Service, Salem, Missouri

Nelson F. Rogers, Wayne M. Harrison, John S. Crosby

TERRITORY SERVED BY THE

CENTRAL STATES FOREST EXPERIMENT STATION

FOREST SERVICE

U. S. DEPARTMENT OF AGRICULTURE